WRD RESOURCE ROOM

DINO copy #1

VEGETATION ALONG GREEN AND YAMPA RIVERS AND RESPONSE TO FLUCTUATING WATER LEVELS, DINOSAUR NATIONAL MONUMENT

FINAL REPORT

N. Timothy Fischer

Mollie S. Toll

Anne C. Cully

(Research Assistants)

and

Loren D. Potter

(Principal Investigator)

Biology Department

The University of New Mexico

Albuquerque, N. Mex.

Contract No. CX-1200-2-B024

April 30, 1983

TABLE OF CONTENTS

ACKNOWLEDGMENTS

We especially wish to express our appreciation to the personnel of Dinosaur National Monument, particularly Steve Petersburg and Earl Perry, without whose full cooperation and assistance this project would not have been possible. They made countless arrangements and provided the excellent logistic support so essential to the success of this type of field research. We thank the boatmen, Day de la Hunt, Jim McBrayer, Bob Ratcliff, Barbara Warner, and Gary Young, not only for their providing of safe but exciting journeys, but for their interest and field assistance in the project. We also appreciate the unpaid field assistance provided by Buck Cully and Wolky Toll on several trips. Excellent support was provided in plant identifications and in manuscipt typing by Beth Crowder.

INTRODUCTION

Dinosaur National Monument contains three types of river systems within its boundaries, offering a unique comparative basis for study of the relationship between river conditions and the accompanying riparian vegetation. The Yampa River is the last large tributary of the Colorado River drainage system which is still free-flowing. Except for scattered pockets of exotics, such as tamarisk (Tamarix pentandra), its riparian vegetation is typical of nearly pristine conditions. Its water levels fluctuate with the natural runoff from the Rocky Mountain snowmelt in the spring, with maximal levels attained in May-June. The early summer floods in Yampa Canyon produce a natural scouring of river beds, sandbars, and floodplains. Quite in contrast are the man-controlled fluctuations of the level of the Green River through the Canyon of Lodore, below the dam at Flaming Gorge.

The releases here vary significantly on a daily basis, though little on an annual basis, in response to hydroelectric power needs of distant cities. The current range of water level variation is far below pre-dam natural flood levels, resulting in the exposure of a formerly flooded and scoured zone to plant succession. Differences in frequency and amplitude of water level fluctuations, and differences in chemical and physical properties of the water released from the dam, may contribute to some significant differences in the present vegetation along the Green River, with respect to that of the Yampa. Below the junction of the Yampa and the Green is a compromise of the two with intermediate conditions.

We have set as the principal objective of this study of the Yampa

River, the determination of the roles of natural flow and water level fluctuations on the stream morphology and the ecology of the riparian and floodzone vegetation. The contrast to the physical and biological changes which have occurred on the Green since the construction of the dam at Flaming Gorge will provide an objective basis for predicting the changes which would occur on the Yampa River should an impoundment be made upstream.

The critical area for potential change on the Yampa is the zone below the current natural maximum flood level and above the regulated maximum discharge level, were a hydroelectric dam constructed upstream. Potential vegetational invasion of this zone will depend to a large extent on the substrate materials exposed and the relationship to new varying water levels as a source of soil moisture.

To accomplish this objective, several lines of study have been pursued on all three river corridors, with principal emphases on the Yampa and upper Green, respectively. Detailed studies were made of selected areas deemed representative of situations most sensitive to river level fluctuations (beach areas, back eddies, and gravel islands). Special attention was given to conditions present and plant invasion response in the zone between high flood level and the low level (the floodzone). Consequently, sampling was scheduled for low water conditions of August and September. Relief and substrate types were monitored in coordination with vegetative cover and density measures. Soil texture characteristics were measured in relation to areas of tamarisk seedling establishment. Establishment history of tamarisk on both the upper Green and the Yampa was further investigated by dating stems of mature tree specimens.

Historic photographs of streamside vegetation provided further documentation of vegetative distribution and species composition over time. Major vegetational communities or dense stands of individual taxa were mapped along the stream courses, as an overview of the range and extent of conditions which exist now, and which would be subject to change on the Yampa and lower Green. Extensive plant collections were made to identify unknown species encountered on transects, and to contribute to the taxonomic array currently known from Dinosaur National Monument.

This report begins with a review of environmental parameters of the study area and relevant floristic studies. The many forms of information collected in this study are then organized by major river corridors (Yampa, upper Green, and the Green below the confluence) so as to construct a picture of the present vegetation and the critical factors which control this distribution for each corridor. Transect data, representative photos, and mapping (proceeding from upstream to downstream sampling locations) are used to illustrate this picture of present vegetation. Early photos paired with 1982 retakes are used to document vegetative continuity or change on each corridor. Finally, we discuss potential areas for change on the Yampa (and lower Green), based on examples from the two corridors with altered flow regimes and other related studies of manipulated rivers.

DESCRIPTION OF THE STUDY AREA

Geology and Physiography

The Yampa River

The Yampa River flows generally westward within Dinosaur National Monument. The river has cut a deep and often narrow canyon into the sedimentary rock of the east end of the Uinta uplift. From Deerlodge Park (elevation 5600 ft.) at the eastern end of the Monument to its confluence with the Green River at Echo Park the Yampa River travels 46.5 miles and drops 540 ft. in elevation.

The average river gradient from Deerlodge Park to the confluence with the Green is 11.6 ft./mile with a range between 1 ft./mile at Deerlodge Park (mile 46.5, measured from the confluence) and above Big Joe Rapids (mile 23.5) to 31 ft./mile at Tepee Rapids (mile 36.4). The upper 23 miles of the river averages 17.0 ft./mile, while the lower 23.5 miles (below Big Joe Rapids) averages 7.4 ft./mile.

The aerial distance between Deerlodge Park and Echo Park is 25.1 miles. The sinuosity of the river, or the ratio between the channel length and the down-valley distance, is 1.85. The sinuosity of the upper 23 miles is 1.51 and that of the lower 23.5 miles is 2.22. Leopold (et al., 1964) defined a meandering stream as one with a sinuosity greater than 1.50, thus, the Yampa can be described as meandering, with an increasing sinuosity toward the lower end.

The Yampa River contacts six geologic units within the canyon. These are given below by increasing age and follow the nomenclature used in the USGS geologic maps (Hansen 1977a and 1977b, 1978; Rowley et al. 1979; Hansen and Carrara 1979; Hansen et al. 1979; Hansen and Rowley 1979):

1. Weber Sandstone (Upper Pennsylvanian)

This cliff-forming, buff-colored sandstone contacts the river for less than

a mile at the entrance to the canyon (mile 45), but it dominates the canyon walls below mile 21 (Fig. 1). Through this reach, the canyon is characterized by a high sinuosity and low average river gradient. The high sheer cliffs often terminate with sandstone talus slopes, but sometimes extend directly into the river. Overhangs are formed occasionally in the canyon wall along the outer curves of meanders. In places, such as Harding Hole, the sandstone on the inside of the meanders is eroded to slopes and terraces. Quaternary river terraces at the base of the Weber sandstone also occur at Castle Park, Laddie Park, Outlaw Park, and Echo Park.

2. Upper Morgan Formation (Middle Pennsylvanian)

The upper part of the Morgan Formation is a resistant stratum composed of sandstone interbedded with limestone (Fig. 2). It contacts the river for approximately one mile near the entrance to the canyon, and extensively between Big Joe Rapids and the confluence with the Green. The reddish colored, ledgy cliffs of this unit are particularly prevalent between miles 8.2 and 3.0 where it forms the base of the Weber Sandstone cliffs.

3. Lower Morgan Formation (Middle Pennsylvanian)

In the lower part of the Morgan Formation, shale and siltstone interbed with the limestone to form a relatively weak structural unit. Exposures of this unit at river level occur principally between miles 44 and 30, but it is also seen at Big Joe Rapids (mile 23.5) and Warm Springs Rapids (mile 4). Due to its high erodability, contact with the river or large side drainages often results in the undermining and consequent structural failure and landsliding of the more resistant strata above. Such landslide deposits can be seen on the right bank of the river at Anderson Hole, Tepee Draw, Browns

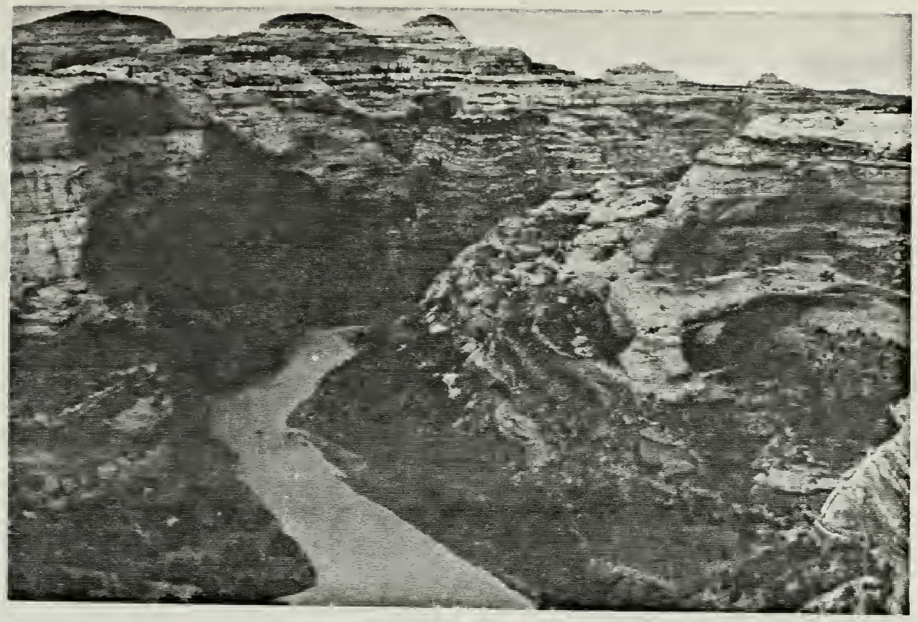


Fig. 1. The Weber Sandstone dominates the Yampa Canyon below Big Joe Rapids. As seen here at Harding Hole (Mile 20.3) the canyon is often wide with a broad floodplain within this geologic unit.

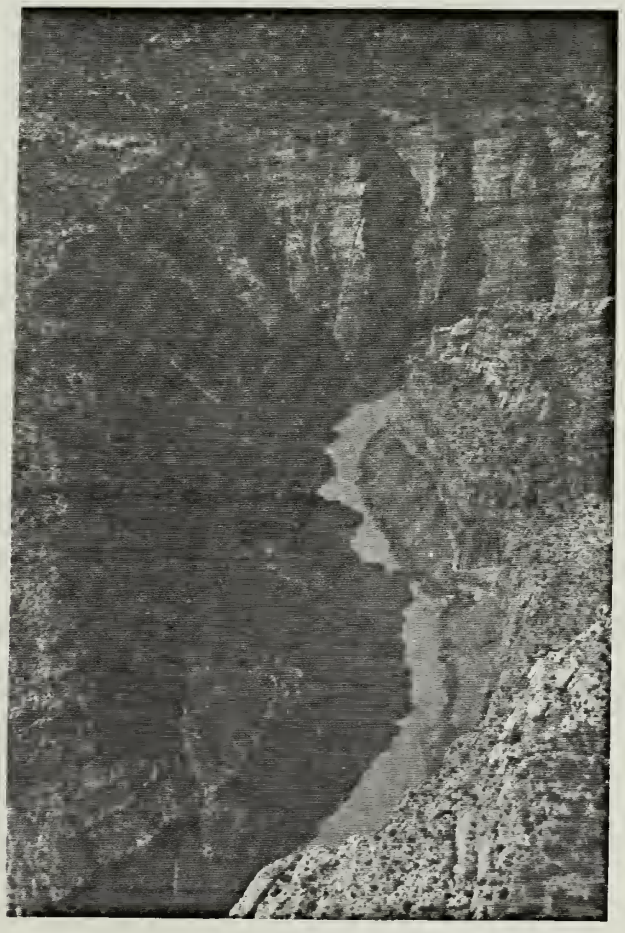


Fig. 2. The Upper Morgan Formation as it appears near Happy Hollow (Mile 44) forms a narrow canyon with ledgy cliff walls and steep talus slopes extending directly to the river.

Draw, Lake Bench, Starvation Valley, and Warm Springs Cedars. Outwash of rubble from these areas produces constrictions in the river channel which may result in the formation of gravel islands, riffles, or rapids.

4. Round Valley Formation (Lower Pennsylvanian)

This is a cherty limestone which underlies the Morgan Formation. Exposures of Round Valley Limestone are limited to the upper half of the canyon where it is often covered by landslide or talus slope deposits. Good exposures are found intermittently between miles 30.3 and 23.5.

5. Doughnut and Humbug Formations (Upper Mississippian)

These two minor formations are frequently treated as one functional unit. They consist of clayey shale (Doughnut) and very fine-grained sandstone interbedded with shale and limestone (Humbug). Exposures of these formations are limited to a short reach of river between miles 30 and 25.4. Where exposed, the Doughnut forms slopes and the Humbug forms ledgy slopes or cliffs.

6. Madison Limestone (Lower Mississippian)

The oldest rock exposed by the Yampa River in the Monument is this fine- to medium-grained cherty or dolomitic limestone. It is the least important formation in the canyon, being exposed in only a few places between Little Joe Rapids (mile 29.5) and Five Springs Draw (mile 26).

At river level, Quaternary alluvial and colluvial deposits comprise the most important substrates for vegetation. Talus slopes are the principal geomorphic structures along the river's edge. These are usually armored with gravel or stone along the flood zone. Where the current is swift, bare bedrock forms the river banks. Sand deposits are found where the current is

slowed by an obstruction of rubble (as above Big Joe and Warm Springs Rapids) or where the water eddies below a constriction of the channel (at Anderson Hole and Haystack Rock). Meanders are also areas of sand deposition, particularly along the inner curves where the current is slow. Gravel bars and islands occur periodically along the entire length of the river in a variety of channel situations.

The Green River from Lodore Ranger Station to Echo Park

The 18.5 miles of river between Lodore Ranger Station (mile 243.7, from the confluence with the Colorado River) to Echo Park flows generally southward through the deep and narrow Canyon of Lodore, named in 1869 by J.W. Powell. In one section of this canyon (between Rippling Rock and Limestone Draw) the right wall rises over 3000 ft. above the river. By contrast, the highest wall on the Yampa is 1700 ft. in the area of Warm Springs.

The sinuosity of this section of river is 1.27, well below the level of a meandering river. The vertical drop is 275 ft., giving it an average gradient of 14.9 ft./mile. The range of gradients runs from 1 ft./mile at the ranger station and immediately above Disaster Falls (mile 237) to a drop of 30 feet in a half mile at Hell's Half Mile (mile 231.8). The upper six miles are relatively flat, averaging 2.5 ft./mile, while the lower 12.5 miles drop rapidly at 18.2 ft./mile.

The geology of the canyon is relatively uniform with two formations not encountered on the Yampa. These are:

1. The Uinta Mountain Group (Precambrian)

The upper 15.5 miles of the Canyon of Lodore are cut into these very

old, coarse- to medium-grained, pebbly, quartzitic sandstones (Fig. 3). The resistant nature of these strata is probably responsible for the canyon's characteristic straightness, depth, and narrowness. The canyon walls through this section are of high, blocky cliffs, usually reddish in color, and with talus slopes at river level.

2. Lodore Formation (Upper Cambrian)

At approximately three miles above the confluence with the Yampa, the Green contacts this formation of ledgy sandstone interbedded with glauconitic, slope-forming shale. This contact lasts for less than three-quarters of a mile.

For approximately one mile below the contact with the Lodore Formation, the Green contacts the Madison Limestone. Below this, it flows through the Mitten Park fault where the Humbug, Doughnut, Round Valley, and Morgan Formations are all exposed in a nearly vertical dip within a half mile. Weber sandstone lines the last mile of the river above the confluence.

The Green River from Echo Park through Split Mountain

At Echo Park, the Green River (now combined with the flow from the Yampa) makes a sharp bend to the north and again contacts the Mitten Park fault. It then turns to the west and enters Whirlpool Canyon. This canyon runs generally westward for 8.5 miles. The sinuosity is relatively low (1.17) and the average gradient is 12 ft./mile. The upper 1.5 miles of the canyon passes through sandstone of the Uinta Mountain group. The next 3.5 miles are through the Lodore Formation and the final 3.5 miles of river contacts in succession the Madison Limestone, Round Valley Formation, Morgan Formation, and Weber Sandstone.

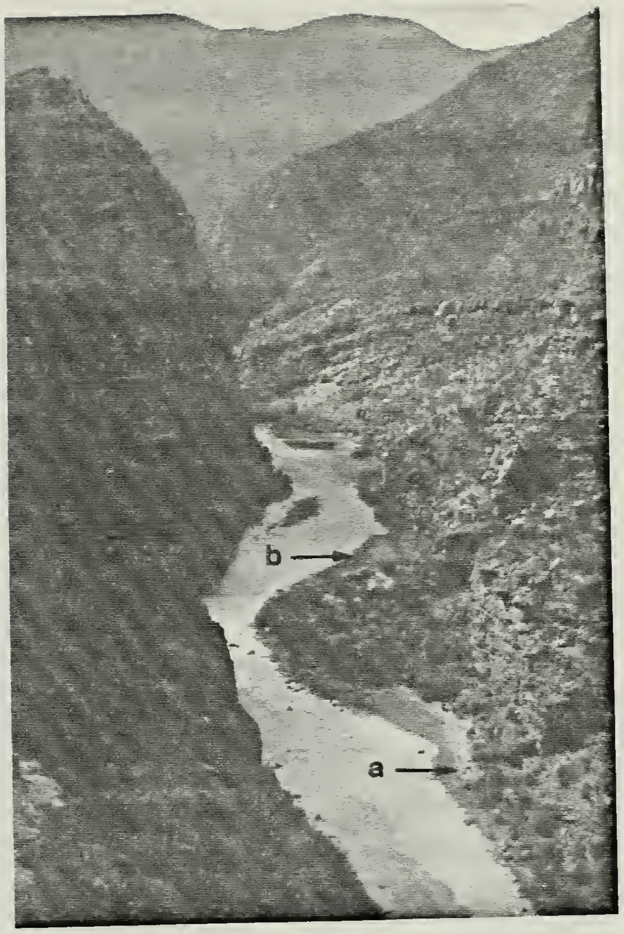


Fig. 3. The depth and narrowness of the Canyon of Lodore is well illustrated here. The walls are rock from the Uinta Mountain group. The alluvial outwash in the foreground is the site of Kolb campground. Point A marks the location from which Fig. 53 was taken. Point B marks the gravel island which was sampled in August (Table 18),

Below Whirlpool Canyon, the river meanders for seven miles through an open valley of Quaternary alluvium and a few exposures of Mesozoic sandstone. The sinuosity of this reach is high (1.90) and the gradient averages less than one ft./mile. The channel is wide and braided, forming several islands. The occurrence of several intermittent and extinct channels indicates the dynamic nature of the river through this section.

In its final eight miles within the Monument, the river flows through Split Mountain, a continuation of the Uinta uplift, and then leaves the uplift for the broad alluvial valleys to the south. The canyon through Split Mountain is relatively straight. The high river gradient (17.9 ft./mile) produces a swift current and several rapids.

Flow Regimes

The Yampa River

Immediately above the eastern Monument boundary, the Yampa is joined by the Little Snake River from the north. The Yampa above the Little Snake drains approximately 3400 sq. miles. The drainage basin of the Little Snake is aout 3700 sq. miles. Although it has a larger drainage basin, the discharge from the Little Snake is generally lower than that of the Yampa above their confluence due to the generally lower elevations and precipitation of its headwaters.

Flow data are available from U.S. Geological Survey gauging stations on the Yampa at Maybell, Colorado (approximately 20 miles above the confluence with the Little Snake) and on the Little Snake at Lily, Colorado (10 miles above the confluence). These records date from 1916 and 1921, respectively, and include daily discharge data since the 1950s (USGS 1961 to present, 1964 to present).

A discharge gauge has also been established by the Park Service on the Yampa near the entrance to the canyon, just below Deerlodge Park. Although this station has the advantage of measuring the flow of the Yampa as it enters the Monument, its record lacks the length and continuity of the USGS stations. For this reason, the past flows of the Yampa through the Monument is best measured as the sum of the discharges at Maybell and Lily.

The average discharge of the Yampa at Maybell over the period of record is 1,550 cfs. Peak flows occur in May or June. The maximum flow on record is 17,900 cfs from May of 1917. The minimum flow is 2.0 cfs, recorded in July, 1934. The peak base flow (on the average amount of the peak flow which is not contributed by direct runoff) is 7,000 cfs. Flood recurrence intervals are shown in Fig. 4.

The average discharge of the Little Snake over the period of record is 573 cfs. Peak flows generally coincide with those of the Yampa. The maximum flow on record is 14,200 cfs in May, 1926. The river may be completely dry in August or September. The peak base flow is 3,500 cfs. Recurrence intervals are shown in Fig. 4.

The combined flows from Maybell and Lily indicate an average flow through the Monument of 2,123 cfs with a peak base of 10,500 cfs. From the maximum historic flows of the Yampa and Little Snake, the potential peak of the Yampa through the Monument is over 32,000 cfs; however, the highest combined flow since 1950 is 20,520 cfs, which occurred on June 9, 1957. Since the Little Snake is often dry during the summer, the minimum flow through the Monument is primarily controlled by the upper Yampa. The combined flows recorded during the study period are shown in Fig. 5.

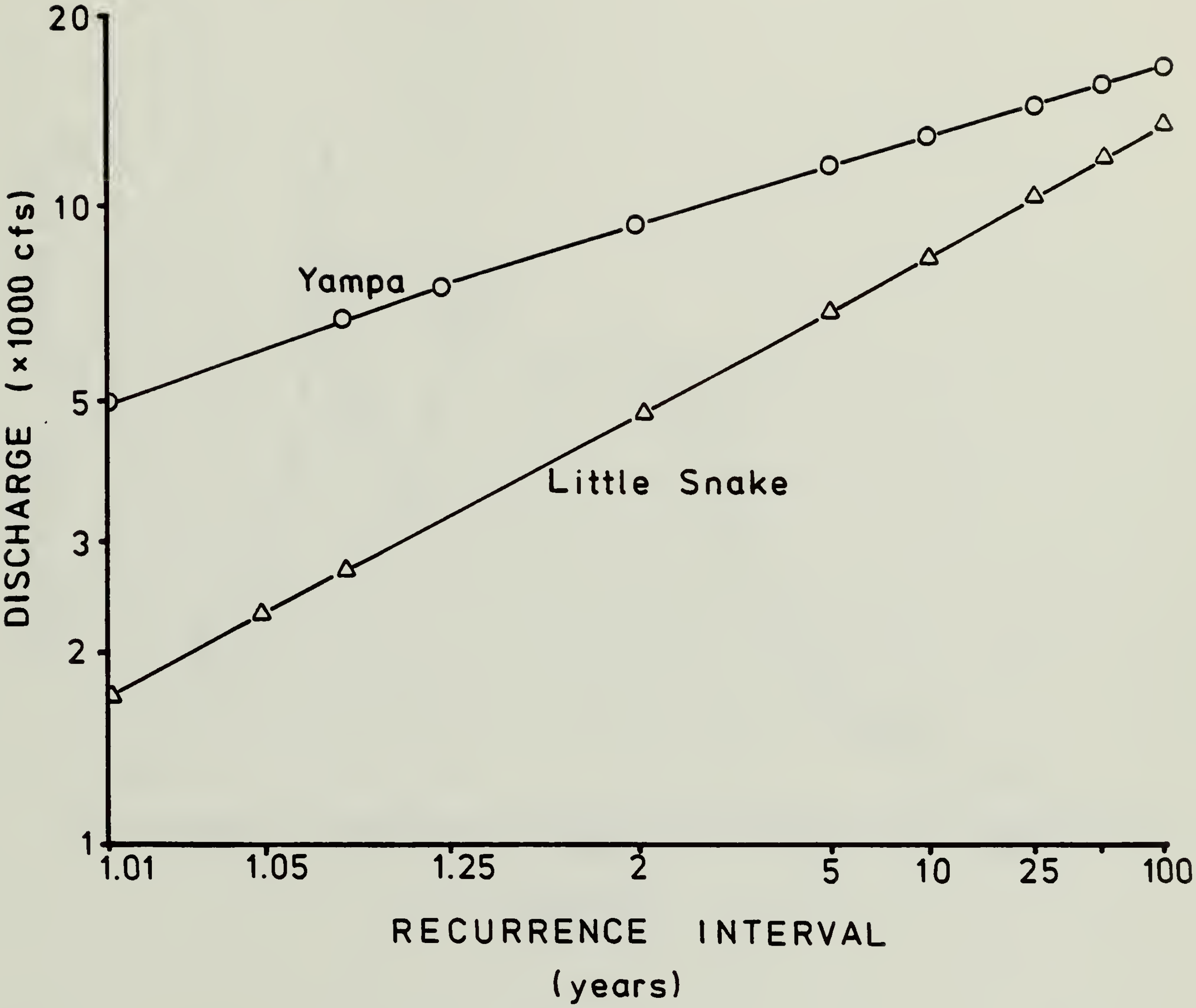


Fig. 4. Flood recurrence curve for the Yampa River (at Maybell, Colorado) and the Little Snake River at Lily, Colorado (redrawn from Sumison, no date).

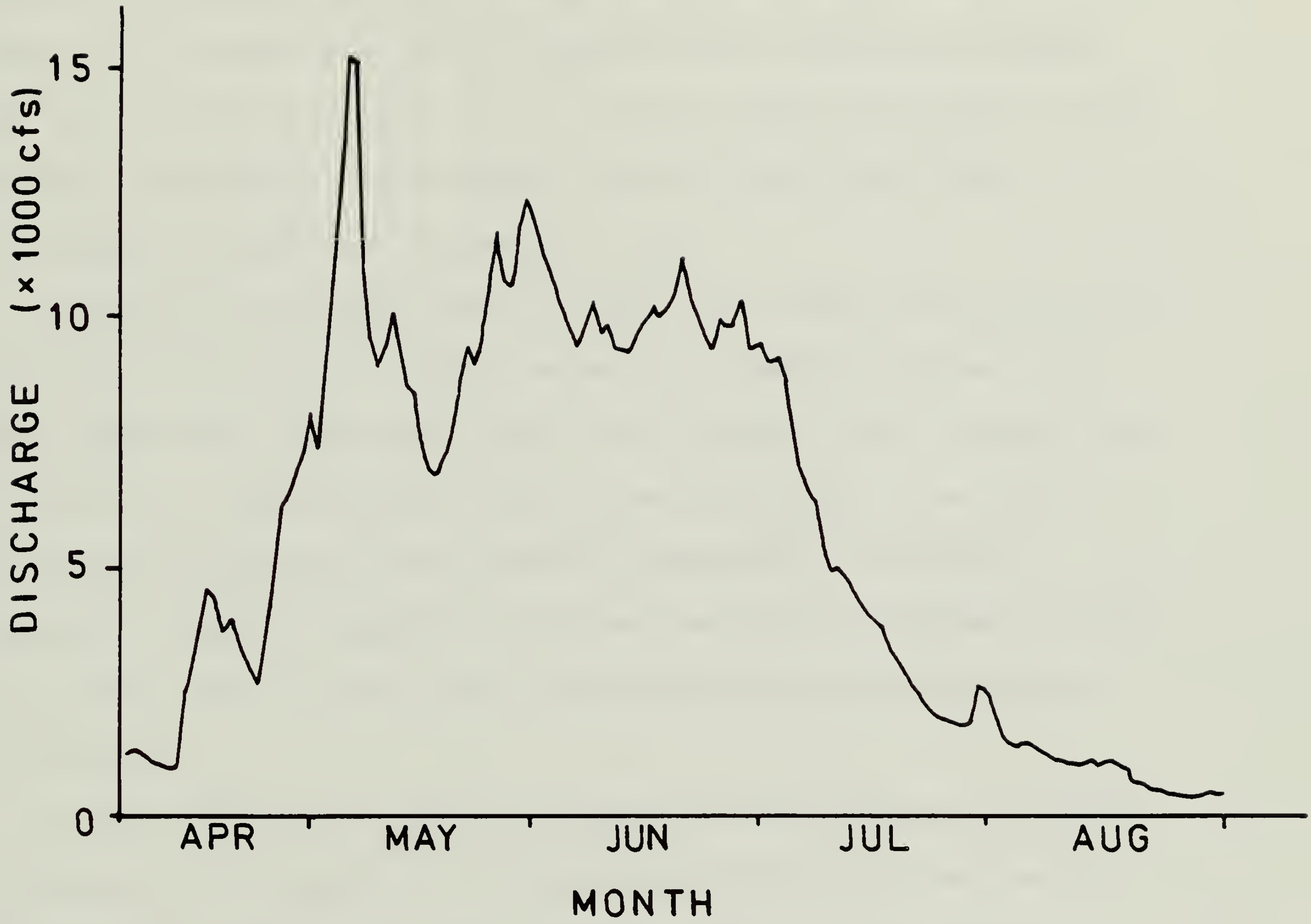


Fig. 5. The combined flow of the Yampa River and the Little Snake River during the high water period of the study period.

The Green River above the Yampa

Flow data for the Green River in Lodore Canyon comes from the USGS gauging station at Greendale, Utah, approximately one-half mile below Flaming Gorge Dam and 46 miles above the Gates of Lodore. The published data from this station are daily averages and do not reflect the daily fluctations of release from the dam associated with peak energy demands. These data also do not include inputs or losses between the station and the Monument, in particular the additional flow from Vermillion Creek, approximately 3 miles above the Gates of Lodore.

The record from Greendale began in 1950. The average flow since that time has been 2,049 cfs. Prior to completion of Flaming Gorge Dam, the highest peak flow on record was 19,600 cfs on June 12, 1957. The peak base was 9,000 cfs. Peaks occurred in May or June, but usually a few weeks later than the Yampa due to more northerly headwaters. The minimum recorded flow prior to completion of the dam was 208 cfs in November, 1958. Note the similarity of these data to the combined flow data from Maybell and Lily above.

In 1963, Flaming Gorge Dam was completed and much of that year's flow was retained in the reservoir. The minimum flow during this year was 2.3 cfs recorded in March. Since then, the regulated flow usually does not exceed 5,000 cfs and the minimum is usually held above 700 cfs.

The Green River below the Yampa

The USGS gauging station at Jensen, Utah, four miles south of the Monument boundary, is the first point of discharge measurement on the Green below the confluence with the Yampa. The average discharge at this station since the continuous record began in 1946 has been 4,355 cfs. The maximum was recorded during June, 1957, at 36,500 cfs. The minimum was 102 cfs in December, 1904. Prior to 1963, the peak base flow was 7,500 cfs.

Although the Green River is regulated by Flaming Gorge Dam, having a daily fluctuation in discharge but little seasonal change, the input from the Yampa gives the section below the confluence a distinct seasonal flood period. The maximum discharges below the confluence are lower than those prior to 1963 and there is now a daily fluctuation added to the seasonal fluctuation. In recent years, the peak flows at Jensen have ranged from 7,360 to 22,100 cfs and low flows have been between 1,000 and 2,000 cfs.

Vegetation Zones and Floristics

General taxonomic sources which include the Monument area are by Harrington (1954), Holmgren and Reveal (1966), and Welsh (1973). The vegetation of the Monument has been the focus of several extensive taxonomic studies (Flowers 1963; Holmgren 1962a, 1962b; Holmgren and Reveal 1966). Welsh (1957) describes the ecological relationships between vegetation types and geological formations for the Monument in Utah.

Dinosaur National Monument lies on the border of the Uinta Basin Florisitic Division of the Intermountain Region defined by Cronquist et al. (1972) and the Mountain and Plateau area described by Costello (1954). Plants characteristic of the semi-desert shadscale zone (Cronquist et al. 1972) are common in the Monument around the Quarry (Welsh 1957), but also intrude into the canyon at Echo Park, Island Park, and Jones Hole. Within the Monument the Yampa River descends through lower montane, pinyon-juniper, sagebrush, and mountain shrub vegetation zones. These zones are often mixed rather than clearly distinguishable, depending on slope, aspect, and substrate of the talus and side drainages entering the river. The Green River also descends through canyons with mixed woodland and shrubzone components on the slopes and canyon floors adjacent to the riparian zone.

The vegetation along the river corridors was determined in three bands running parallel to the channel. There were designated the floodzone, riparian zone and upland zone (Fig. 6). The floodzone is the area directly influenced by high river discharge. The lower boundary of this zone is marked by the river, and the upper boundary by a change in species composition from scour-tolerant to scour-intolerant forms, and by an accumulation of driftwood or other debris and litter above the boundary, or floodline.

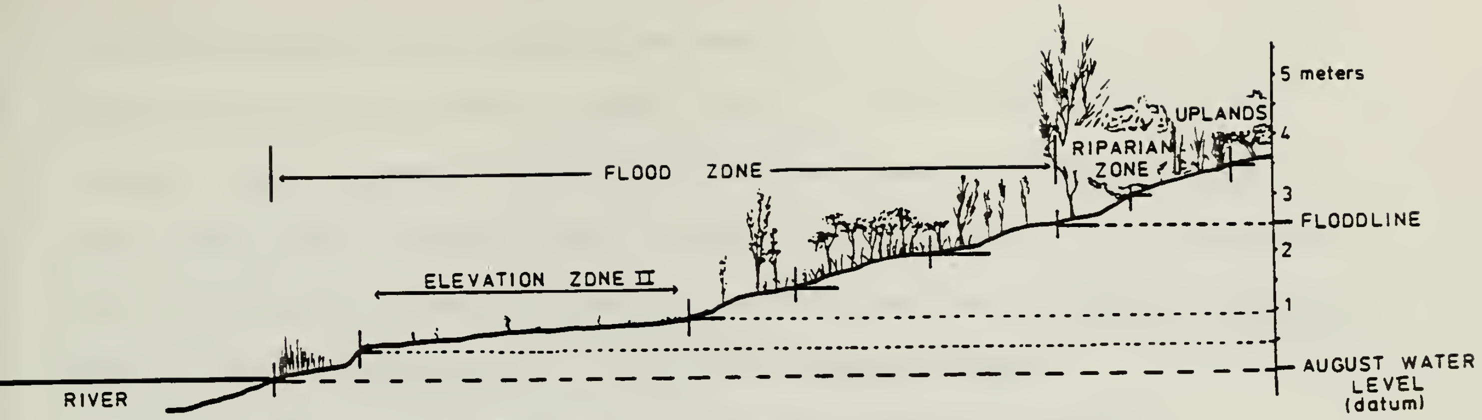


Fig. 6. Diagrammatic view of a bank slope showing the division of elevational and vegetational zones above the river level.

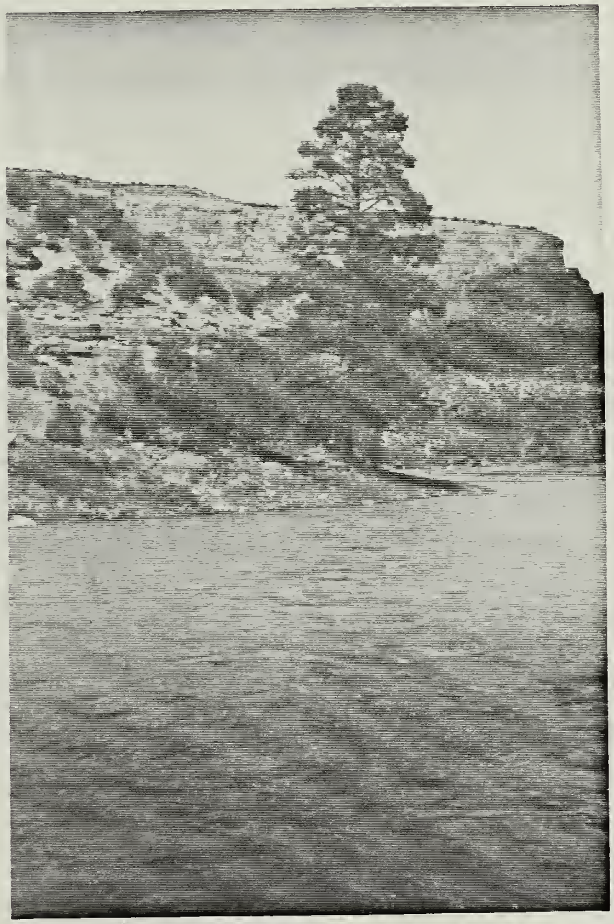


Fig. 7. Ponderosa pine was found in a few locations along the floodline of the Yampa.

the Green and Yampa Rivers within the Monument; and in places may be the most abundant plant species along the Yampa River, if late summer seedlings are included. Other introduced species include downy chess (Bromus tectorum), an annual grass which dominated several heavily disturbed areas in the upland zone, such as burns and high-use campgrounds, crested wheatgrass (Agropyron desertorum), Russian thistle (Salsola kali), and alfalfa (Medicago sativa).

Occasionally coniferous species ordinarily confined to higher altitudes occur in isolated stands along the Yampa River. Ponderosa pines (Pinus ponderosa) have been noted at the floodline (Fig. 7). These plants appeared vigorous, although there were signs of scouring damage on the upstream side of trunk bases. Douglas-fir (Pseudotsuga taxifolia) the river level, as just above Warm Springs, and above Box Elder Campground.

METHODS

Timing of Field Work

Data were collected during four trips to the Monument, each of which included rafting the length of the Yampa River from Deerlodge Park to Echo Park and the Green River from Echo Park to Split Mountain. Three of the four trips also included rafting down the Green from Lodore Ranger Station to Echo Park. Boatmen, rafts and other necessary equipment were provided by the Park Service personnel at the Monument.

The first trip was from April 19 to 26, 1982. This was a combined reconnaissance trip for all of the groups involved in the study. All river corridors were travelled. Potential study sites were located, photographs were taken, and an initial map was made of the stream-side vegetation of the Yampa and Green above Split Mountain. A small collection of plants was also made.

A second trip was made from June 11 to 15 to observe the Yampa River at high flow. Only the Yampa and Green below the confluence were rafted. A larger plant collection was made on this trip and photographs were taken to document the flood stage. As the peak flow had occurred the week before our arrival, the river level observed on this trip was just below the maximum of the year, but indications of the high water line were present. During this visit, the Monument's photo library was examined for historical photos to document the vegetation of the Green River prior to construction of Flaming Gorge Dam, the sequence and rate of change since the dam, and the historical vegetation on the Yampa River.

In early August (the 3rd to the 15th), all river corridors were run again. The purposes of this trip were: (1) to take measurements of the vegetation at selected sites on the Yampa and Green, both above and below the confluence,

(2) to relocate and rephotograph the sites in the historical photos from the Monument library, (3) to rephotograph some of the photo sites from the June trip in order to document seasonal changes in vegetation and (4) to collect plants from the flood zone area.

The final trip was from September 20 to 29. The purposes of this trip were: (1) to observe the vegetation at the end of the growing season, (2) to rephotograph sites which were missed on the August trip, (3) to refine and finalize the vegetation map of the Yampa River corridor, (4) to collect any plants not previously seen or not previously in flower, (5) to collect soil samples from sand bars and beaches which exhibit successful tamarisk seedling establishment to determine whether substrate texture may be influencing reproduction of this species, and (6) to cut and age tamarisk from the Green River and from Big Joe Rapids on the Yampa. Vegetation measurements such as those collected in August were not taken on this trip.

Also in September, the Park Service, through the cooperation of the Forest Service, provided helicopter time so that we were able to photograph the Yampa canyon and parts of the Green in 35mm color slides during this low water period. The purposes of these photos were to determine the approximate area of the flood zone and to improve the accuracy of the vegetation map. The former proved to be unfeasible due to the unavailability of highly detailed, small-scale base maps of the canyon and the inconsistency of scale in the photographs.

Vegetation Surveys

Seven locations were selected on the Yampa River for vegetation analysis, three above Big Joe Rapids, three below, and the area of Big Joe Rapids itself. These locations are described in Table 1. Sites were selected on the basis of their potential to be strongly influenced by high river discharges, as indicated by their physiography and the nature of their substrates. Types of areas which

Table 1. Characteristics of vegetation transect locations

	Location	River Mile	Transect Numbers	Location on River [Right]or [Left]bank	Approx. River Gradient (ft./mile)	Bank Morphology at low water	Geology	Comments
Yampa above confluence	Anderson Hole	41.8	1,2	on outside curve [R]	7	broad bare sand beach	lower Morgan Fmn. (limestone/sandstone/ siltstones)	
	Tepee Rapids	36.4	3,4,5	on outside curve just above rapids [R]	15	silted gravel beach	lower Morgan Fmn. (limestone/sandstone/ siltstones)	
	Haystack	34.6	6,7,8	straight stretch just down stream from an outside curve [R]	21	broad bare sand beach	Round Valley Limestone overlain by Morgan Fmn.	
	Big Joe Rapids	23.8	9,10,11	on outside curve; just above rapids [R]	< 1	fairly steep, heavily vegetated bank	Round Valley Limestone overlain by Morgan Fmn.	
	Mather Hole	17.7	12,13,14	on outside curve [L]	18	broad bare cobble beach; gravel island and channel	Weber Sandstone	extensive sand deposit in front of alcove in tall cliff
	Laddie Park	10.7	15,16, 17,18	fairly straight stretch [R]	2	broad bare beach	Weber Sandstone	
	Box Elder	2.1	19,20,21	on inside curve (large point bar) [R]	3	broad bare beach	Weber Sandstone	
Green above confluence	Kolb CG	234.5	22,23,24	slight outside curve (downstream side of point bar) [R]	25	vegetated sandy beach (23 & 24 are on Old gravel "island")	Uinta Mt. Fmn. (red quartzitic sandstone)	just below riffle
	Harp Falls	233.9	25,26	outside curve [L]	11	sandy beach	Uinta Mt. Fmn.	back eddy just below rapids
	Rippling Brook	230.6	27,28	in pool with riffles above & below [R]	5	silted gravel island	Uinta Mt. Fmn.	deepest part of Lodore Canyon (3400' from river to rim)
	Limestone CG	228.2	29,30,31	fairly straight stretch [L]	9	fairly steep vegetated sandy bank	Lodore Fmn. (sandstone w/some siltstones & shale)[a]	
Green below confluence	Stateline CG	219.4	32,33,34	on point bar (inside curve) [R]	4	bare sand beach	Lodore Fmn. overlying Uinta Mtn. Group at river level	
	Compromise CG	217.7	35,36,37	straight stretch [L]	< 1	bare sand bar & beach	Lodgepole Limestone overlain by Deseret Limestone	

[a] less than a mile down stream passes into Lodgepole and later Deseret Limestones.

were judged to be most sensitive to flooding were sand bars, sand beaches, gravel bars, and gravel islands.

At each site, from two to four randomly located line transects were run, each starting at the water's edge and extending up the bank, perpendicular to the river. Each line was extended beyond the point at which a change in vegetation or substrate indicated that flooding was no longer a major influence. Each transect was thus of different length, but each included the entire flood zone and part of the riparian or upland zones.

Plant foliar coverage was measured by the point intercept method. A metal rod was dropped at each 10 cm point along the line. Contact was recorded if the rod touched any living plant tissue. At each point, the surficial substrate type was also recorded. The class of substrate type was also recorded. The classes of substrate used were silt and clay (determined by feel), sand (less than 2 mm in diameter), gravel (2 mm-10 cm), cobble (10 cm-30 cm), stone (30 cm-100 cm), boulder (greater than 100 cm), litter, and log.

Density of woody perennials was measured in a one meter wide belt transect on the right-hand side of the line (looking up from the water's edge). The number of stems at ground level was recorded for each square meter. Density of herbaceous plants was measured in a 30x30 cm quadrat in the lower left-hand corner of each square meter quadrat in the belt.

Relief along each transect was measured using a Suunto PM-5/360 PC hand-held Clinometer. From these data, each transect was divided into elevational zones, each representing one-half meter rise above the water line. Coverage, density, and substrate data from within each of these zones were combined. Mean, standard deviation, and 95% confidence intervals (using the normal approximation of the binomial distribution for coverage and the normal approximation of the Poisson distribution for density; Pollard, 1977) were calculated for each parameter within each zone at each site.

In addition to the sampling of the seven sites on the Yampa, six sites were selected and sampled identically on the Green, four above the confluence and two below (Table 1). The sites selected above the confluence represented the spectrum of physiographic types sampled on the Yampa, while those below the confluence represented only a sandy beach and a sand bar. In most cases, the transects were extended beyond the historic floodline and into the upland zone or the relictual riparian zone, using the same criteria as on the Yampa. At Compromise Campground an impenetrable stand of tamarisk prevented sampling of the entire historic flood zone.

Tamarisk Seedling Establishment

In September, five of the sample sites on the Yampa River were revisited, Tepee Rapids, Big Joe Rapids, Mather's Hole, Laddie Park and Box Elder. Each of these sites exhibited successful tamarisk seedling establishment on sandy substrates. The sand bar at Tepee was approximately 200 yards above the gravel island sampled in August and that at Mather's Hole was about 50 yards downstream of the August sampling area. The others were all within the August sampling sites.

At three of the sites, Tepee, Laddie Park and Box Elder, the seedlings were found in distinct linear zones across a seemingly uniform sandy substrate. At Big Joe, they were more widespread over the flood zone, but there were patches of bare sand present. At Mather's Hole, the sample site was an eroding sand deposit with a dense, uniform covering of tamarisk seedlings.

A single transect was run at each of these sites. Transects ran from the water's edge to the floodline and relief was measured as in August. Tamarisk seedling density was measured at each meter on the transect line in four

30x30 cm quadrats. Two locations along the transect with successful seedling establishment were selected and a 10 cm deep hole was dug at each. Soil samples were collected from each of the visibly distinct horizons exposed. Similarly, one or two locations with no seedlings present were excavated and soil samples were collected. At Mather's Hole, no bare areas of sufficient size were found for sampling and only one soil sample was collected from the transect.

The samples were returned to the University of New Mexico, oven-dried at 105 C for 24 hours, weighed, and dry-sieved through the following series of standard soil sieves: Nos. 10, 18, 35, 60, 120, and 230 (the numbers indicate the number of grids per inch of sieve surface). The sieving separated the sample into seven textural classes: gravel, five divisions of sand (from very coarse to very fine), and fine (which included both silt- and clay-sized particles). Some samples with a high clay content formed aggregates which did not break apart in the sieving process. These will cause an exaggeration of coarse particle sizes and an under-estimation of the fines. Sieve contents were inspected for aggregates and their presence was recorded. Percentage composition of the seven particle size classes was calculated for each horizon sampled.

Tamarisk Ages

Two sites were selected on the Green River in Lodore Canyon for cutting and aging tamarisk stands. The first was a gravel island between Trailer Draw and Buster Basin (mile 238.5) and the second was a gravel bar across and downstream from Wild Mountain Campground (mile 229.3). A total of twelve plants were cut. The criteria for cutting were: (1) the plant should have a distinct central trunk with no branching or spouting evident below six inches in height, (2) there must be some living foliage present above the trunk and (3) the diameter

and bark formation must indicate that the plant is old with respect to others in the vicinity. With two exceptions, plants that were aged were from below the historic flood line. All cuts were made completely through the trunk within six inches of the ground surface.

At Big Joe Rapids on the Yampa River, 17 plants were cut and aged. Three distinct terraces were observed here at low water, each having established tamarisk plants. Plants were cut from all three terraces. It was hoped that from this collection a correlation could be established between stem diameter and age, and therefore an effort was made to collect a range of diameter sizes from this site. Otherwise, the criteria for selection and the method of cutting were the same as for the Green.

Comparative Photographs

Two types of comparative photographs were used, recent and historic. The recent photo pairs were taken as color slides and show the same location in June and September (high and low flood stages) of the study period. Only the Yampa River was included in this aspect of the study.

Historical photographs from the Monument library included all river corridors but the majority were from the Canyon of Lodore. The oldest were from the 1871 Powell expedition taken by E.O. Beaman and J.K. Hillers. The photo stations of this collection were relocated and rephotographed in 1969 by E.M. Shoemaker and H.G. Stephens (1969, 1975) for the US Geological Survey. Thus in some cases, we were able to produce a series of three comparative photos for a single location. All historical re-photos were taken as 35mm black-and-white. Many of the 1871 and 1969 photographs were taken with a wider angle lens than we had available. When we were unable to incorporate the entire field of view of the older photograph, our interest was in the portion showing vegetation along the river.

Mapping

Notes on the flood zone, riparian, and upland vegetation on the Yampa River corridor were made on all trips. Major vegetational boundaries were drawn onto a river map as they were observed from the raft. These notes, together with the aerial color slides taken in the September helicopter flight, were used to prepare a map of the stream-side vegetation, using USGS 7.5' topographic maps as a base. The upland and riparian vegetation were mapped as major community types. The flood zone on the other hand was mapped according to dominant species, since yearly flooding prevents the formation of distinct communities.

Plant Collections

Specimens from plant collections made on all four trips to the Monument were pressed and returned to the University of New Mexico for identification. Several hundred plants were collected over the study period, but an attempt was not made to prepare a complete flora of the region. All specimens encountered on vegetation transects were identified, and are listed in the Appendix to this report. Nomenclature follows that of Harrington (1964).

RESULTS AND DISCUSSION

The Yampa River

The vegetation map of the Yampa is presented in Fig. 8. The upland vegetation was categorized as broadly defined communities based on the dominant species observed from the river. These included Blackbrush (BB), Grassland (GR), Pinyon-Juniper (PJ), Mormon tea (MT), Rabbitbrush (RB), Sagebrush (SB), and Shrub (SH), or combinations of the above. The riparian zone, where distinct, was similarly divided according to dominant species, such as Boxelder (BE), Cottonwood (CW), Squawbush (SQ), Tamarisk (TA), and Willow (WI). In some locations one or a few large, isolated individuals of these and other tree species are indicated as points on the map.

The floodzone vegetation did not form continuous communities with easily delimited boundaries. The vegetation of this zone was mapped as patches of dominant taxa, such as Glycyrrhiza (GLYC), Apocynum (APOC), Carex (CARE), etc. Geomorphic notes are indicated in parentheses, e.g., cutbank (C), gravel (G), rock (R), sand (S), and talus (T).

The summer regrowth of vegetation within the floodzone is illustrated in the comparative photographs of Figs. 9, 10, and 11. The vegetation of this zone presents a high visual impact at the sites illustrated here, and is visually distinct from the riparian zone. Most of the growth is from root sprouts of perennials whose spreading root systems have survived the scouring and flooding.

The results of the substrate and vegetation analyses for each of the study sites on the Yampa River are given in tabular form with the discussion of each site. Vegetation composition and distribution patterns did not appear to correlate with size classifications of lithic debris, and hence gravel, cobble,

Fig. 8. Vegetational map of the Yampa River within Dinosaur National Monument. Community types are designated for upland vegetation adjacent to the riparian zone at maximum flood level. Areas along the floodzone dominated by particular species are separately designated by coding of the scientific name. In some areas, geomorphic streamside features are given.

MAP SYMBOLS

Geomorphic Features:

(C) Cutbank
(G) Gravel
(R) Rock
(S) Sand
(T) Talus

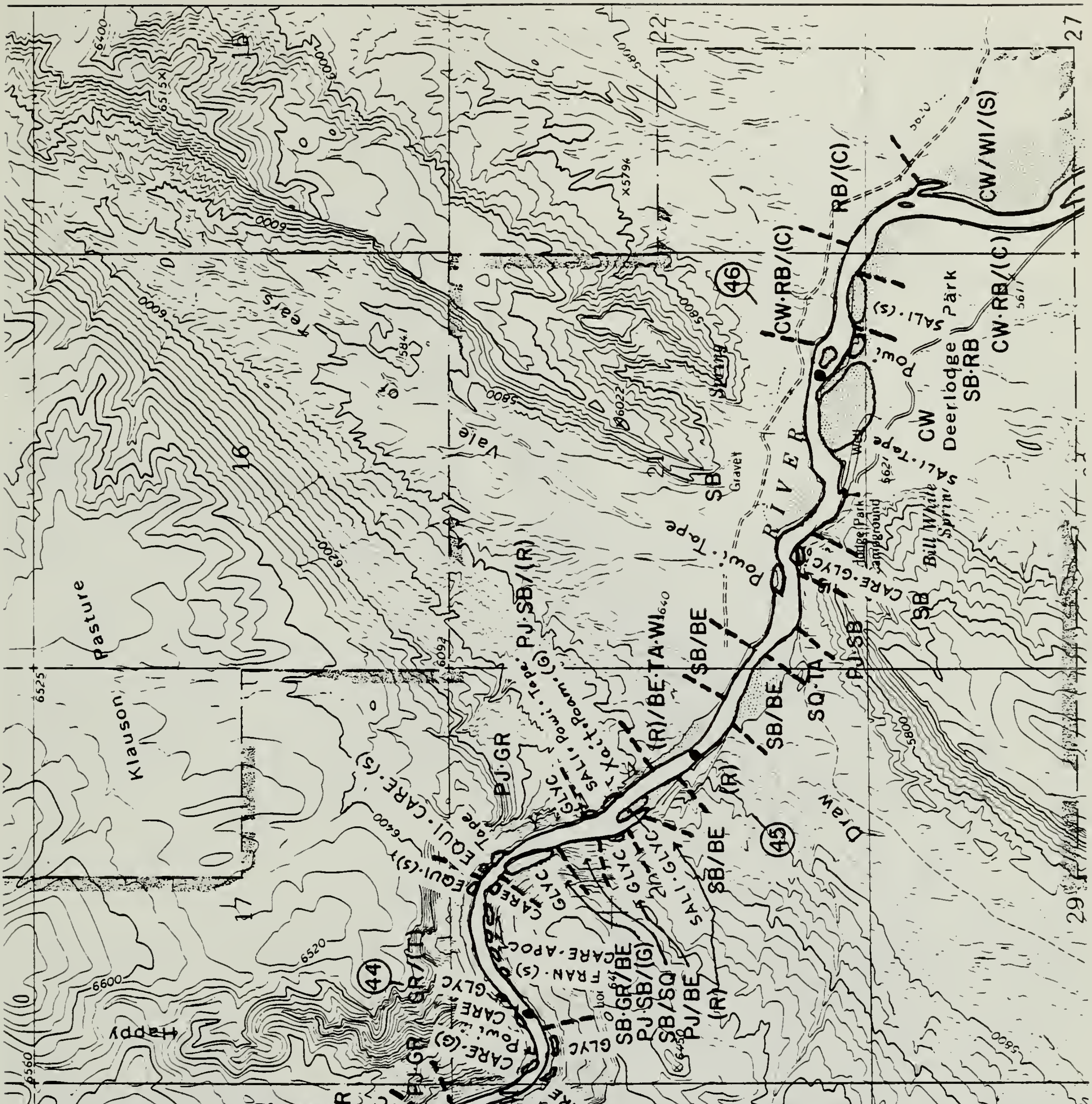
Vegetation Communities: (Upland/Riparian)

BB Blackbrush
BE Boxelder
CW Cottonwood
GR Grass
MT Morman Tea
PJ Pinyon-Juniper
RB Rabbitbrush
SB Sagebrush
SH Shrub
SQ Squawbush
TA Tamarisk
WI Willow

Dominant Taxa of Floodzone:

Acne *Acer negundo*, Boxelder
APOC *Apocynum*, Dogbane
Artr *Artemisia tridentata*, Big sagebrush
ASCL *Asclepias*, Milkweed
Beoc *Betula occidentalis*, Water birch
Brte *Bromus tectorum*, Cheatgrass
CARE *Carex*, Sedge
CEAN *Ceanothus*, New Jersey tea
CHRY *Chrysothamnus*, Rabbitbrush
Cora *Coleogyne ramosissima*, Black brush
ELEA *Eleagnus*, Silverberry
ELEO *Eleocharis*, Spike-rush
EQUI *Equisetum*, Horsetail
FRAN *Franseria*, Bursage
GLYC *Glycyrrhiza*, Licorice
Juba *Juncus balticus*, Baltic rush
PHRA *Phragmites*, Reed
Pipo *Pinus ponderosa*, Ponderosa pine
Poam *Polygonum amphibium*
Powi *Populus wislizeni*, Cottonwood
PRUN *Prunus*, Cherry
Rhtr *Rhus trilobata*, Squawbush
SALI *Salix*, Willow
SPAR *Spartina*, Cordgrass
Tape *Tamarix pentandra*, Tamarisk
Xait *Xanthium italicum*, Cocklebur

xx individual trees



Klauson
Pasture
Happy
Vale
Spring
Gravel
RIVER
Draw
Deerlodge
Park
Bill White Spring
MONUMENT
PJ·GR
PJ·SB/(R)
SB/BE
SQ·TA
PJ·SB
CW·RB/(C)
RB/(C)
CW/WI/(S)
SB·RB
CW
CARE·GLYC
EQUI·(s)
SB·GR/BE
PJ·SB/(G)
SB/SQ
PJ/BE
(R)/BE·TA·WI

Fig. 8a.

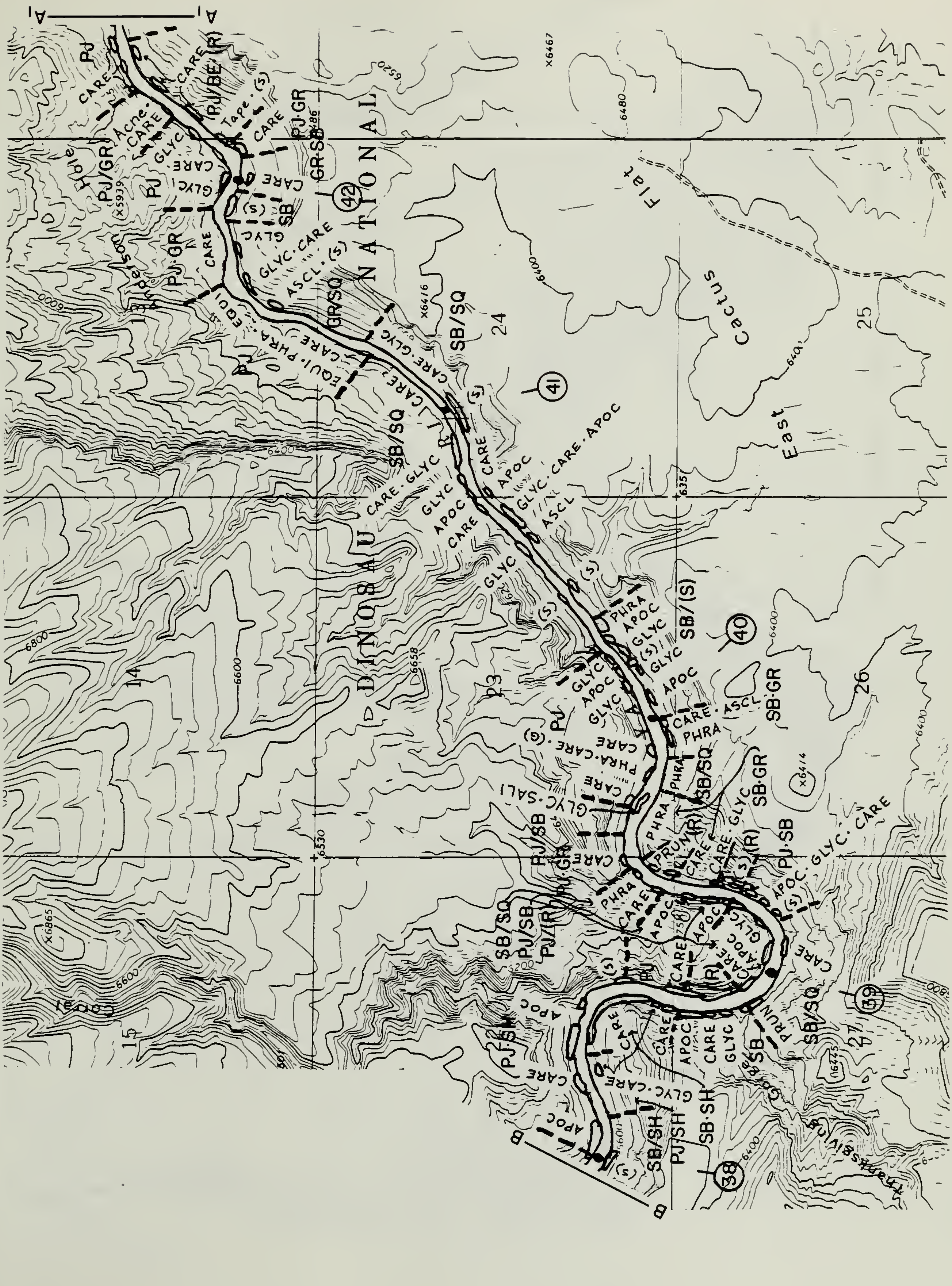
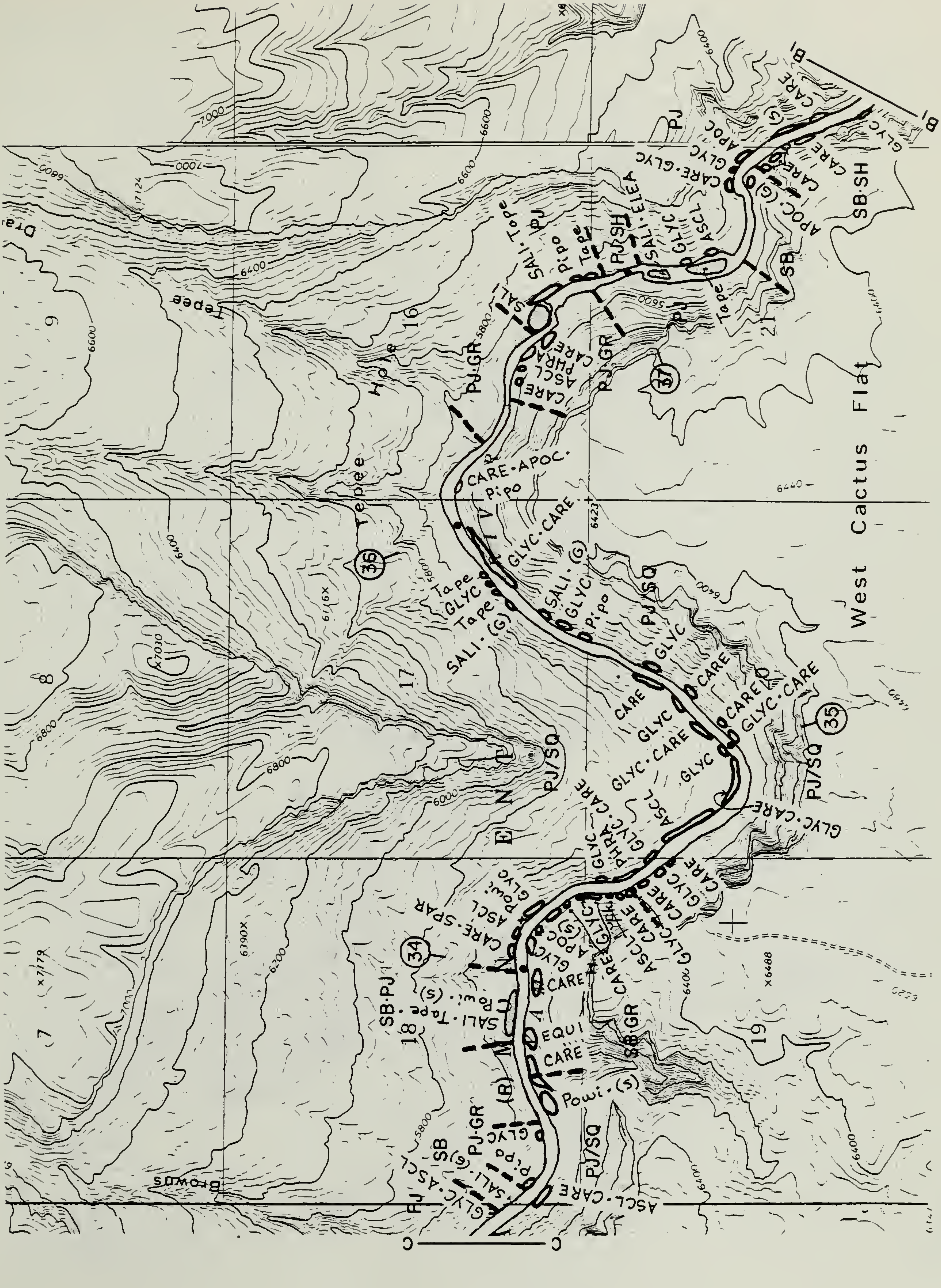

DINOSAUR NATIONAL
Cactus
Flat
East
Harding Hole
A
A'
B
B'
38
39
40
41
42
14
15
23
24
25
26
27
6400
6600
6800
x6865
x6467
x6416
x6414
x6658
PJ
PJ/GR
PJ·GR
PJ/SB
PJ·SB
PJ·SH
PJ/SH
SB/SQ
SB/SH
SB·SH
SB·GR
SB/(S)
GR/SQ
GR·SB
CARE
GLYC
APOC
ASCL
PHRA
PRUN
EQUI
GLYC·CARE
CARE·GLYC
GLYC·SALI
EQUI·PHRA·EQUI
PHRA·CARE·(G)
GLYC·CARE·APOC
APOC·GLYC·CARE
CARE·ASCL
Tape.
Acne.
(S)
(R)

Fig. 8b.


West Cactus Flat
Tepee
Tepee
Hole
Browns
SB·SH
SB
PJ
PJ·GR
PJ/SQ
SB·PJ
SB·GR
PJ/SH
CARE·APOC
Pipo
GLYC·CARE
SALI·(G)
GLYC
Tape
CARE
ASCL
PHRA
APOC
SALI·ELEA
SALI·Tape
EQUI
Powi·(S)
CARE·SPAR
GLYC·ASCL
ASCL·CARE
GLYC·CARE
6400
6600
6800
7000
5800
5600
6000
6200
6423
6440
x6488
x7030
x7179
6390x
6116x
7124
7
8
9
16
17
18
19
21
34
35
36
37
B
B'
C
C'

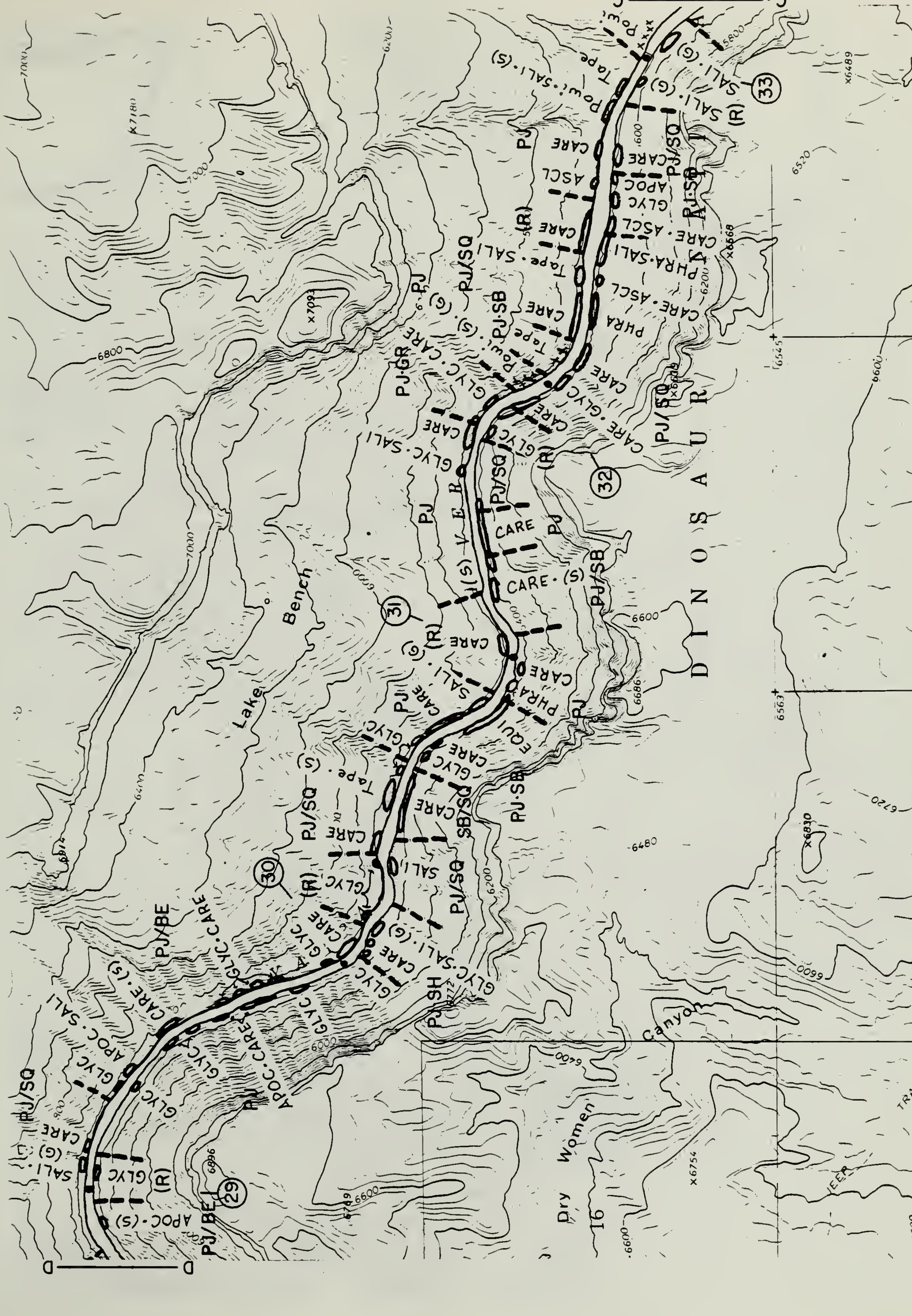
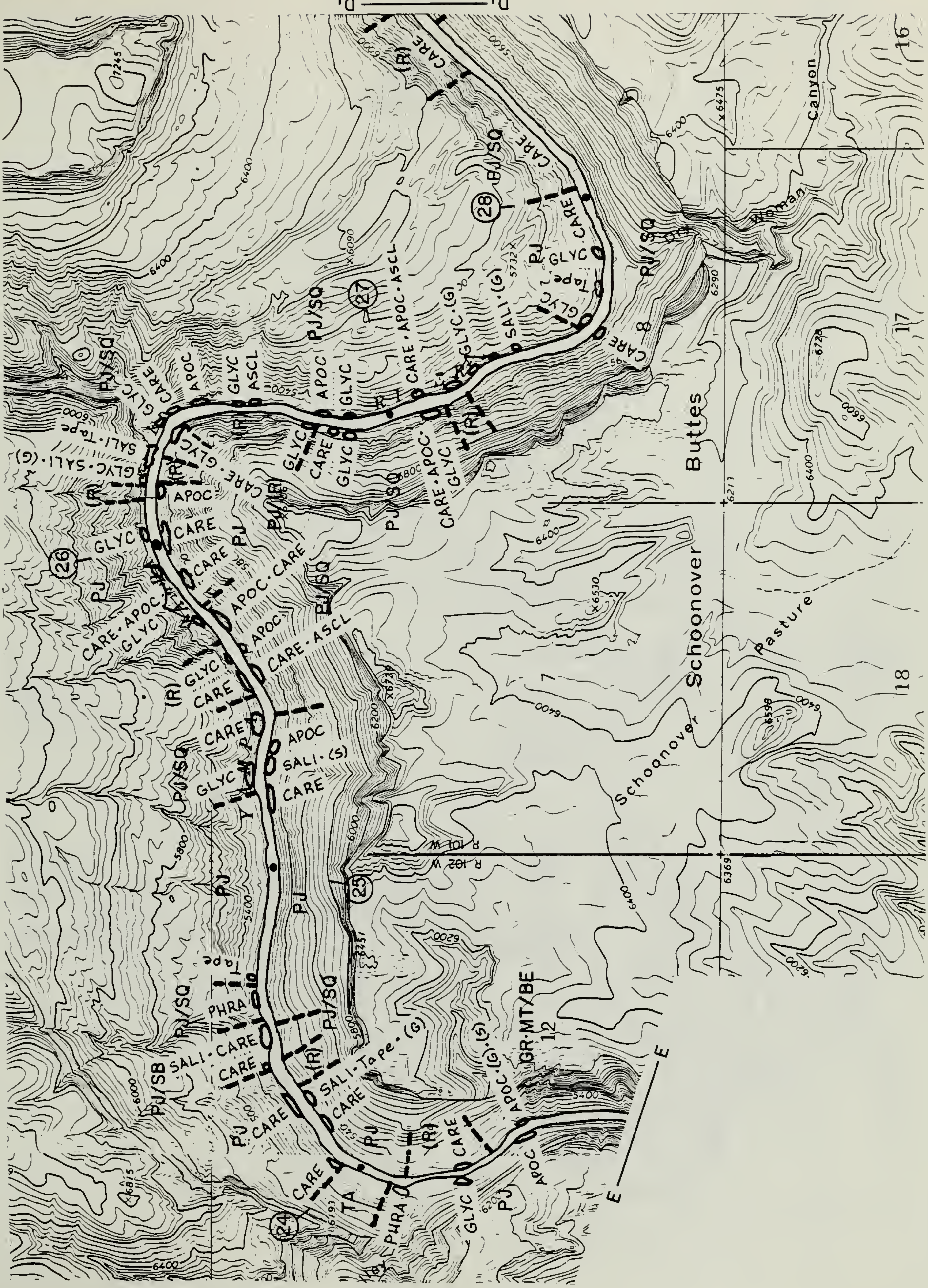


Fig. 8d.



Schoonover Buttes
Schoonover Pasture
Schoonover
Woman Canyon
R 101 W
R 102 W

Fig. 8e.

DINOSAUR NATIONAL
Johnson
Canyon
Harding Hole
Wagon Wheel Point
Bull
Blind
Cleopatras Couch
MANTLE
ROAD
E1
F
15
16
17
18
19
20
21
22
23
CARE·SPAR
CARE·APOC
APOC·GLYC
APOC·CARE
GLYC·CARE
CARE CARE
Tape·CARE·(G)·(S)
GLYC·(S)
GR·MT/SQ
SALI·Tape
SALI·(G)
PJ/(R)
PJ·GR
PHRA
CARE·Juba
SALI·Juba·(G)
CARE·ELEO
PJ·GR·SB/(S)
PJ/GR(S)
PJ/GR
PJ/(R)
GR/BE
PJ/SB
RJ·BB (C)
Tape
x6350
x6223
x7150
x6122
x5820
x5915
x5825

Figure 25

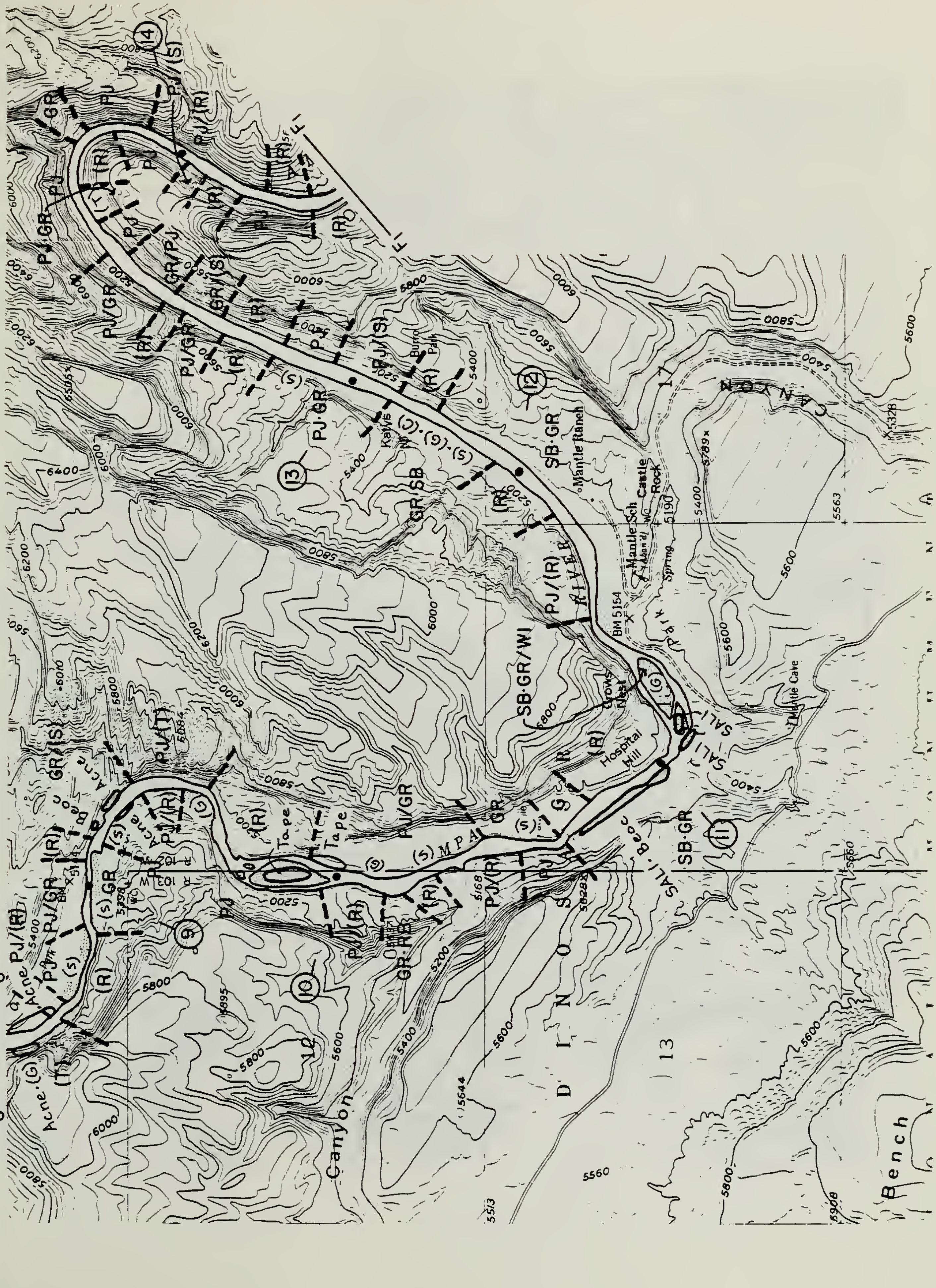
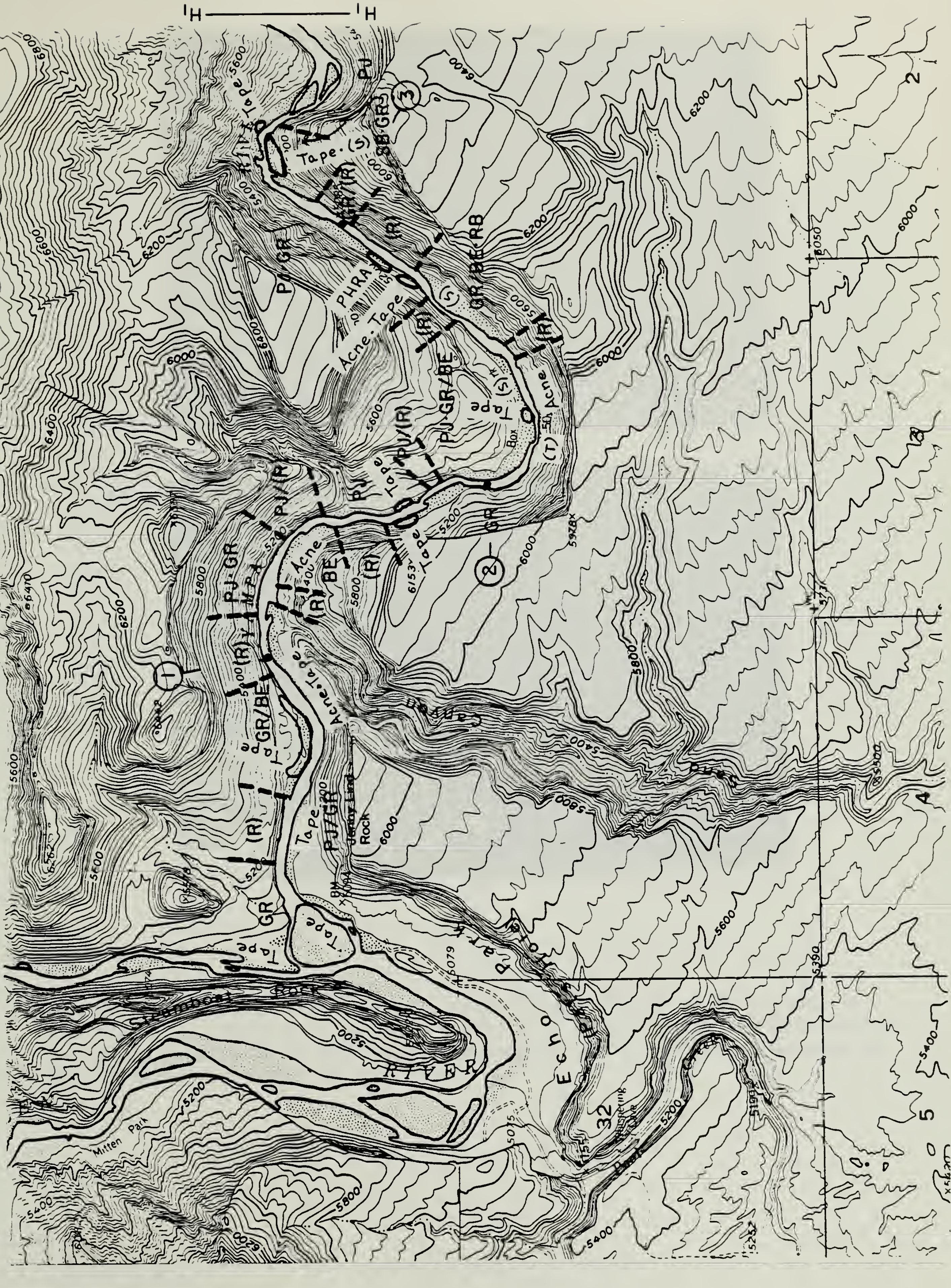

G—G
F—F
Canyon
Bench
Mantle Ranch
Castle Rock
Mantle Sch
Mantle Spring
Mantle Cave
Hospital Hill
Crows Nest
Burro Park
Tape
SB·GR/WI
SB·GR
PJ·GR
PJ/GR
GR·SB
GR·RB
BM 5154
CANYON
RIVER

Fig. 8a

Fig. 8h.


H
H
Steamboat Rock
RIVER
Echo Park
Mitten Park
Jenny Lind Rock
Tape
Acne
PJ/GR
GR/BE
PJ-GR/BE
GR/BE RB
PHRA
Box

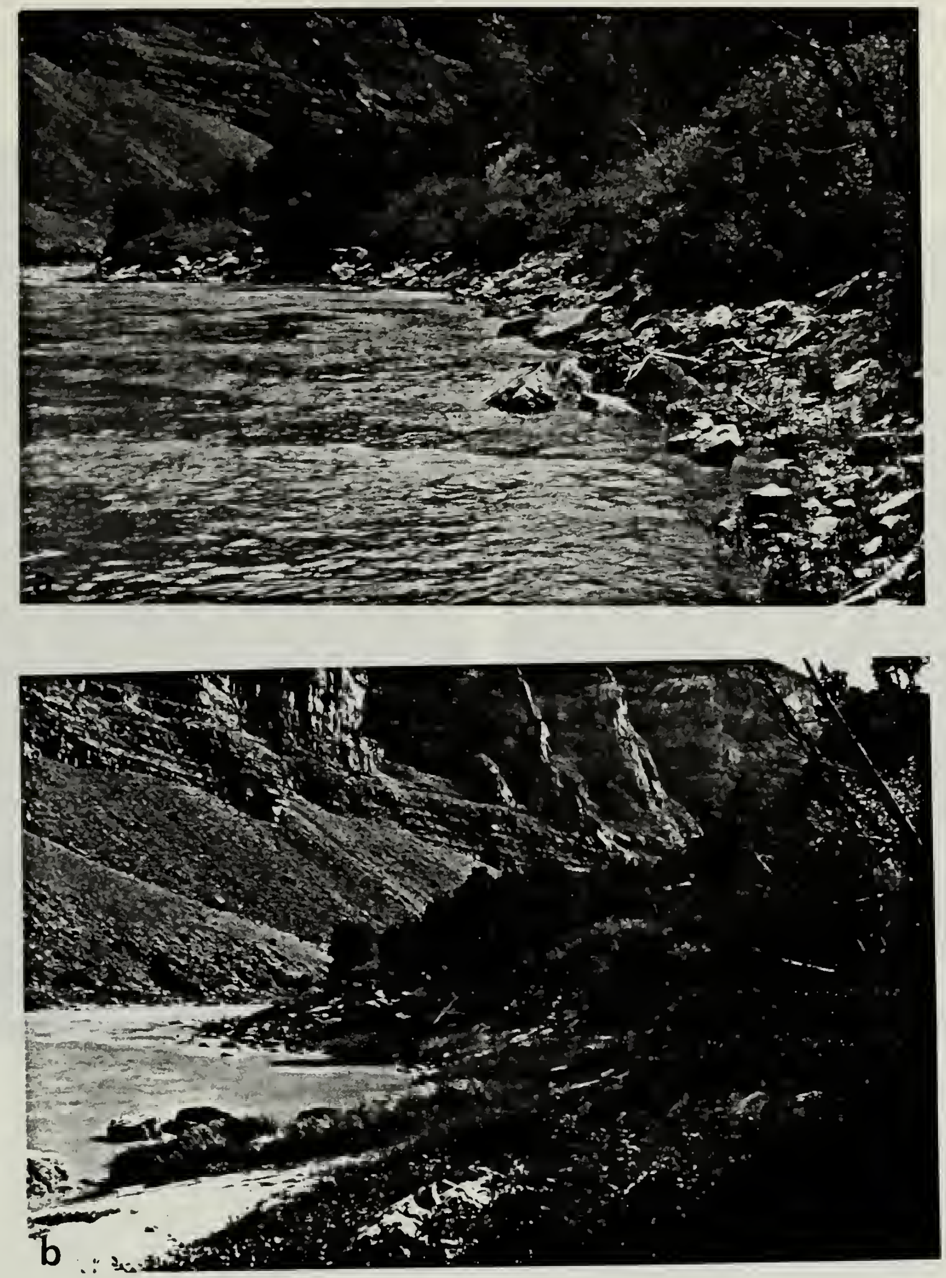


Fig. 9a and b. Photo A was taken in June during the high water period, at Anderson Hole. Photo B is the same location in the September low flow period. The upland vegetation is dominated by squawbush. The distinct appearance of the floodzone vegetation is seen here.

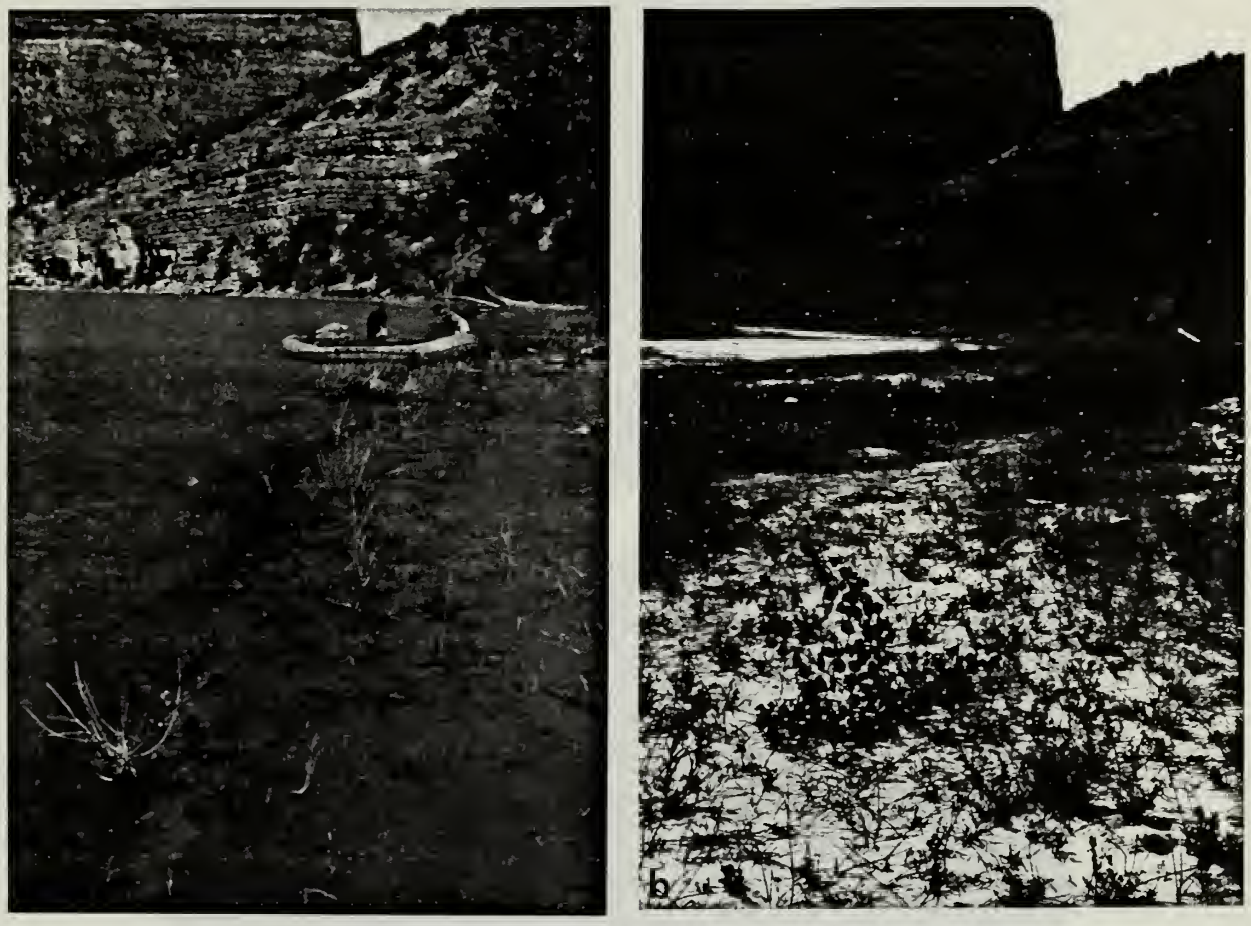


Fig. 10a and b. This pair of photos also illustrates the regrowth of vegetation between the June high and September low water periods. This is the sampling site at Haystack Rock. Note the sapling cottonwoods along the high water line, showing evidence of scouring.

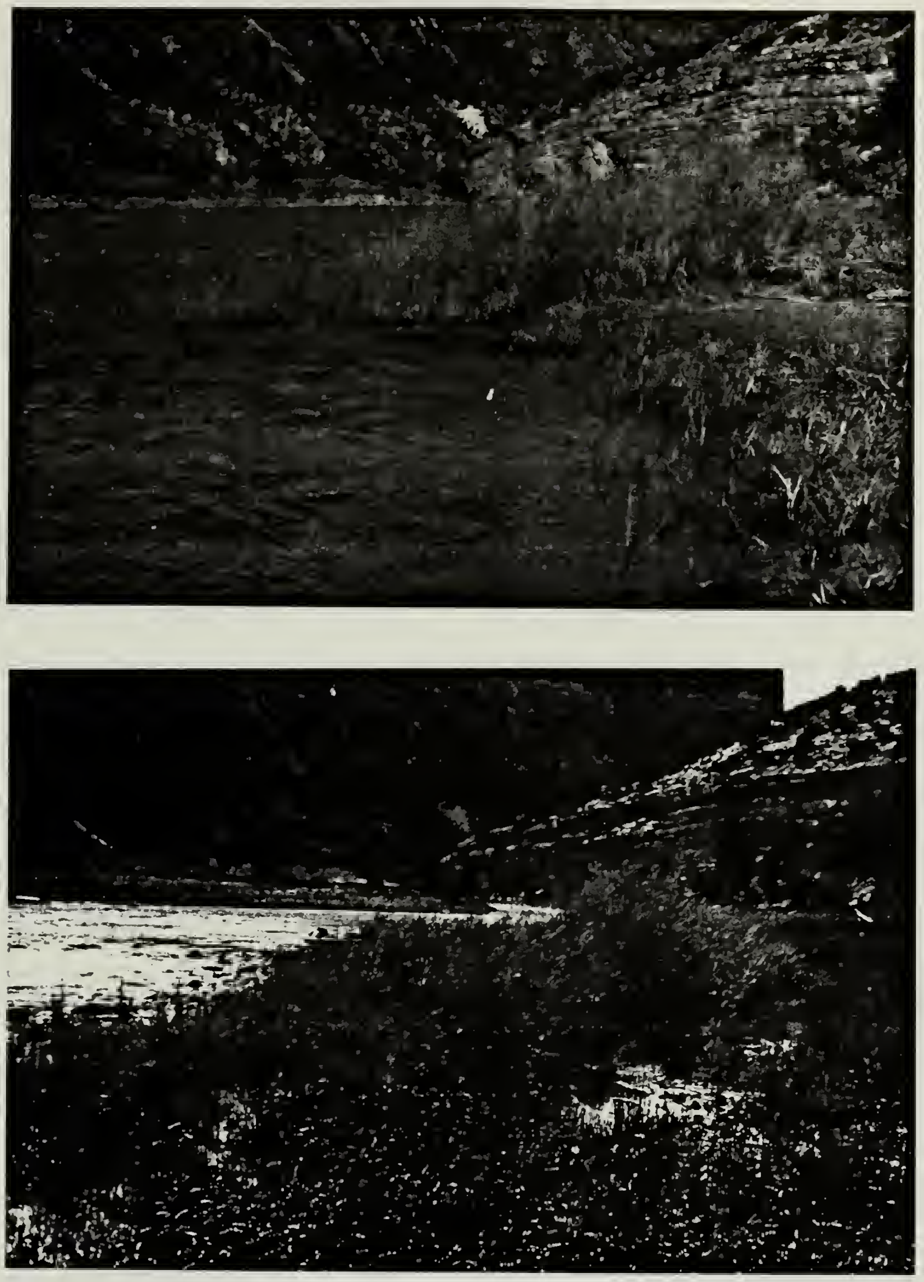


Fig. 11a and b. This stand of sandbar willow near the location of Fig. 10 shows the remarkable ability of this plant to resist scouring during high water (Photo A). Regrowth of <u>Glycyrrhiza</u> is seen in the foreground of Photo B.

and stone data were combined into the "rock" category. No boulders occurred on any of the transects. All coverages were absolute coverage. Total plant coverage does not include overlapping species, and therefore the sum of individual species coverage may exceed the total plant coverage. Vegetation data are here combined into the following classes: horsetails (species of the genus *Equisetum*), sedges and rushes (the families Cyperaceae and Juncaceae), grasses (the family Gramineae), forbs (all herbaceous broad-leaved Angiosperms), and woody perennials. Coverage and density of three herbaceous genera, *Glycyrrhiza* (licorice), *Apocynum* (dogbane), and *Asclepias* (milkweed), which dominate much of the floodzone vegetation of the Yampa River, are presented separately as well as being included in the forbs category. Within the category of woody perennials, willows (*Salix*), cottonwoods, and tamarisk were treated individually, and their seedlings were further distinguished in density measurements.

Density values are given for forbs (including *Glycyrrhiza*, *Apocynum*, and *Asclepias*, as well as listing them separately), willow, tamarisk, cottonwood, and shrubs (not including willow or tamarisk). The densities of cottonwood and tamarisk seedlings are given separately from those of mature plants (non-seedlings).

A list of plant species identified from each site follows the data table for that site. Species are listed according to the category in which they were placed in the data table. A representative profile of each site also accompanies the data tables.

The half-meter elevational zones are designated with Roman numerals, Zone I being nearest the water. Islands and bars had multiple slopes, which were

designated the outer slope--facing the main river channel, the inner slope--facing the nearest river bank, and the bank slope--contiguous with the canyon slopes.

At most sites, the floodline was found either in Zone IV or V (between 2 and 3 m above the August river level). The terraced bank at Mather's Hole exhibited a floodline in Zone III and the gravel bar at the same site showed evidence of scouring above Zone V, probably due to an upwelling of water as it passes over the bar during high water.

Significant differences between adjacent zones for any parameter are indicated on the tables by heavy lines. These were determined by a lack of overlap between the 95% confidence intervals between the zones.

Anderson Hole

The floodzone at Anderson Hole (Fig. 12, Tables 2 and 3), had low total plant coverage (Fig. 13). Plant coverage increased significantly above the floodline, primarily due to shrubs such as squawbush and big sagebrush. Grass and forb coverage was also greater above the floodline. The peak in forb density seen in Zone III was due to a band of *Iva axillaris*.

Of particular interest at this site were rows of cottonwood seedlings, generally running parallel to the river in the moist sand of the floodzone. Mature cottonwoods were present at the site and may have been the seed source.

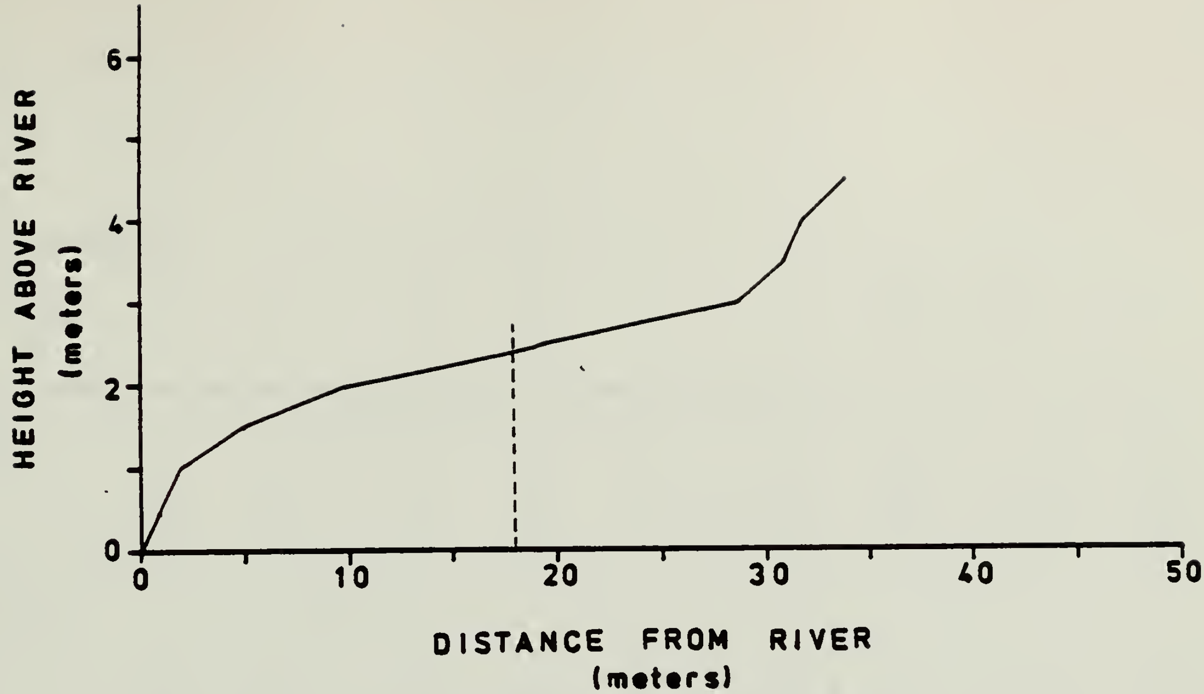


Fig. 12. Representative relief profile for Anderson sampling location. Dashed line represents the floodline.

Table 2. Summary of substrates and vegetation coverage and density for Anderson Hole (Yampa River) sampling location.

Elevation zone	I	II	III	IV	V	VI	VII	VIII	IX
Substrate: mean percent [95% confidence intervals]									
Fines		N	O	N	E				
Sand	96.67	100.00	100.00	99.23	91.58	78.67	43.33	100.00	100.00
	[83.33-99.41]	[72.25-100.00]	[93.91-100.00]	[95.77-99.87]	[86.76-94.75]	[71.44-84.46]	[27.38-60.00]	[72.25-100.00]	[83.89-100.00]
Rock	0.00	0.00	0.00	0.00	0.53	4.67	0.00	0.00	0.00
	[0.00-11.35]	[0.00-27.75]	[0.00-6.02]	[0.00-2.87]	[0.09-2.92]	[2.28-9.32]	[0.00-11.35]	[0.00-27.75]	[0.00-16.11]
Litter	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.00	0.00
	[0.00-11.35]	[0.00-27.75]	[0.00-6.02]	[0.00-2.87]	[0.29-3.76]	[0.00-2.50]	[0.00-11.35]	[0.00-27.75]	[0.00-16.11]
Log	3.33	0.00	0.00	0.77	6.84	16.67	56.67	0.00	0.00
	[0.59-16.67]	[0.00-27.75]	[0.00-6.02]	[0.14-4.23]	[4.04-11.35]	[11.55-23.44]	[39.20-72.62]	[0.00-27.75]	[0.00-16.11]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

Table 2. (continued)

Elevation zone	I	II	III	IV	V	VI	VII	VIII	IX
Vegetative cover: mean percent absolute cover [95% confidence intervals]									
Total cover	0.00 [0.00-11.35]	0.00 [0.00-27.75]	0.00 [0.00-6.02]	0.00 [0.00-2.87]	3.68 [1.80-7.41]	27.33 [20.84-34.96]	30.00 [16.67-47.87]	0.00 [0.00-27.75]	0.00 [0.00-16.11]
Horsetails	N O N E								
Sedges-Rushes	N O N E								
Grasses	0.00 [0.00-11.35]	0.00 [0.00-27.75]	0.00 [0.00-6.02]	0.00 [0.00-2.87]	1.05 [0.29-3.75]	4.67 [2.28-9.32]	0.00 [0.00-11.35]	0.00 [0.00-27.75]	0.00 [0.00-16.11]
Forbs	0.00 [0.00-11.35]	0.00 [0.00-27.75]	0.00 [0.00-6.02]	0.00 [0.00-2.87]	2.63 [1.13-6.01]	4.00 [1.85-8.45]	6.67 [1.85-21.32]	0.00 [0.00-27.75]	0.00 [0.00-16.11]
Woody perennials	N O N E								
Vegetative density: mean number of plants per square meter [95% confidence intervals].									
Forbs	0.00 [0.00-1.28]	0.00 [0.00-3.84]	16.50 [13.55-20.09]	0.00 [0.00-0.30]	3.47 [2.73-4.42]	22.87 [20.57-25.42]	66.33 [57.74-76.21]	33.00 [23.50-46.34]	5.50 [3.07 9.85]
Woody perennials									
Willow	N O N E								
Tamarisk	N O N E								
Cottonwood seedlings	0.00 [0.00-1.28]	0.00 [0.00-3.84]	9.17 [7.04-11.93]	0.85 [0.47-1.52]	0.00 [0.00-0.20]	3.67 [2.82-4.77]	0.00 [0.00-1.28]	0.00 [0.00-3.84]	0.00 [0.00 1.92]
Shrubs	0.00 [0.00-1.28]	0.00 [0.00-3.84]	0.00 [0.00-0.64]	0.00 [0.00-0.30]	0.00 [0.00-0.20]	0.07 [0.01-0.38]	0.00 [0.00-1.28]	0.00 [0.00-3.84]	1.00 [0.27-3.65]

Heavy vertical lines indicate significant differences (at 95% confidence) between adjacent zones.

Table 3.

Plant Species List: Anderson Hole (Transects 1,2)

Grasses	Agropyron repens (L.) Beauv. Distichlis stricta (Torr.) Rydb. Sporobolus cryptandrus (Torr.) A. Gray
Forbs	Chrysopsis villosa (Pursh) Nutt. Eriogonum sp. Franseria discolor Nutt. Iva axillaris Pursh
Woody Perennials	Artemisia tridentata Nutt. Populus sp. Rhus trilobata Nutt. ex. T. & G.

Fig. 13. The relatively bare sand beach at Anderson Hole is shown here. The small plants dotting the surface of the sand are cottonwood seedlings.

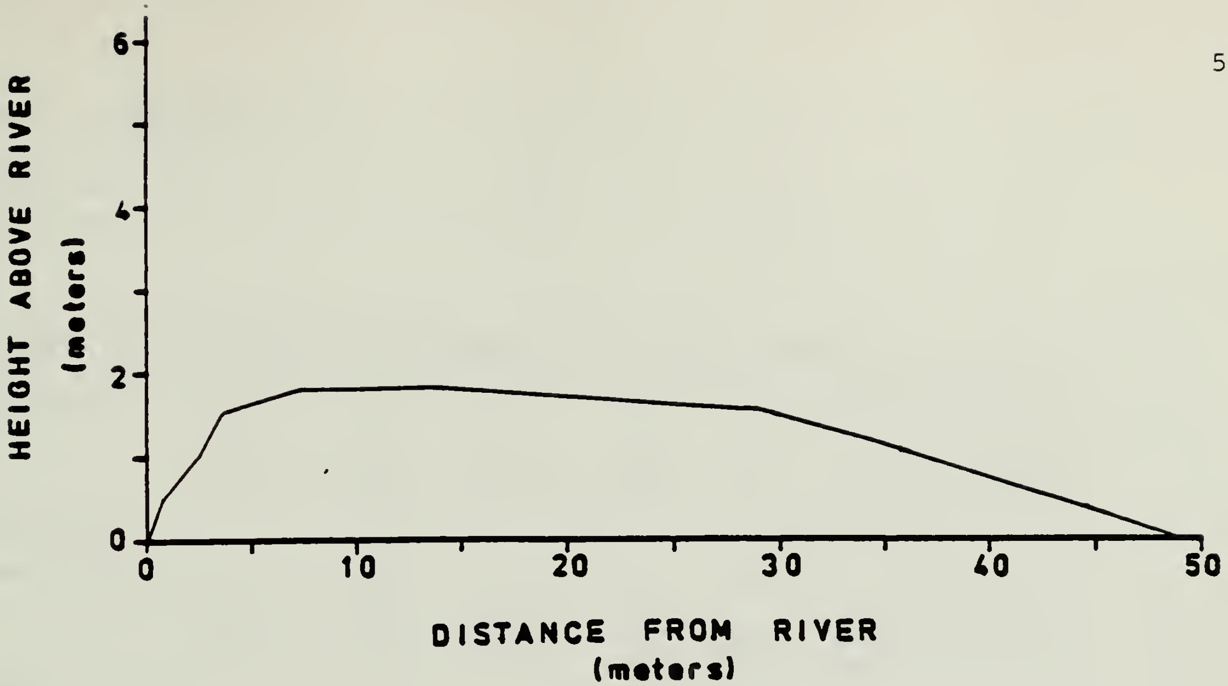


Fig. 14. Representative relief profile for Tepee sampling location. Dashed line represents the floodline.

Table 4. Summary of substrates and vegetation coverage and density for Tepee, Transect 3 (Yampa River) sampli[ng] location.

Substrate: mean percent [95% confidence intervals]

Elevational zone	I	II	III	IV	III	II	I
Fines	55.00	0.00	0.00	0.00	0.00	0.00	16.67
	[34.21-74.18]	[0.00-27.75]	[0.00-27.75]	[0.00-7.13]	[0.00-16.11]	[0.00-16.11]	[7.34-33.56]
Sand	5.00	90.00	100.00	100.00	100.00	100.00	43.33
	[0.89-23.61]	[59.59-98.21]	[72.25-100.00]	[92.87-100.00]	[83.89-100.00]	[83.89-100.00]	[27.38-60.80]
Rock	35.00	10.00	0.00	0.00	0.00	0.00	10.00
	[18.12-56.71]	[1.79-40.41]	[0.00-27.75]	[0.00-7.13]	[0.00-16.11]	[0.00-16.11]	[3.46-25.62]
Litter	5.00	0.00	0.00	0.00	0.00	0.00	10.00
	[0.89-23.61]	[0.00-27.75]	[0.00-27.75]	[0.00-7.13]	[0.00-16.11]	[0.00-16.11]	[3.46] 25.62]
Log		N	O	N	E		

Heavy vertical lines indicate significant (at 95% confidence) differences between adjacent zones.

Table 4. (continued).

Vegetative cover: mean percent absolute cover [95% confidence intervals]

Elevational zone	I	II	III	IV	III	II	I
Total cover	15.00 [5.24-36.04]	30.00 [10.78-60.32]	20.00 [5.67-50.98]	2.00 [0.35-10.49]	0.00 [0.00-16.11]	10.00 [2.79-30.10]	76.67 [59.08-88.21]
Horsetails		N	O	N	E		
Sedges-Rushes	15.00 [5.24-36.04]	10.00 [1.79-40.41]	0.00 [0.00-27.75]	0.00 [0.00-7.13]	0.00 [0.00-16.11]	5.00 [0.84-23.61]	63.33 [45.52-78.12]
Grasses		N	O	N	E		
Forbs (all)	0.00 [0.00-16.11]	20.00 [5.67-50.98]	20.00 [5.67-50.98]	2.00 [0.35-10.49]	0.00 [0.00-16.11]	5.00 [0.84-23.61]	13.83 [5.31-29.68]
G-A-A *	0.00 [0.00-16.11]	20.00 [5.67-50.98]	20.00 [5.67-50.98]	2.00 [0.35-10.49]	0.00 [0.00-16.11]	5.00 [0.84-23.61]	10.00 [3.46-25.62]
Woody perennials		N	O	N	E		

Vegetative density: mean number of plants per square meter [95% confidence intervals]

Elevational zone	I	II	III	IV	III	II	I
Forbs (all)	11.00 [7.27-16.65]	22.00 [14.53-33.31]	44.00 [32.78-59.06]	4.40 [2.91-6.66]	0.00 [0.00-1.92]	0.00 [0.00-1.92]	0.00 [0.00-1.28]
G-A-A *	11.00 [7.27-16.65]	22.00 [14.53-33.31]	44.00 [32.78-59.06]	4.40 [2.91-6.66]	0.00 [0.00-1.92	0.00 [0.00-1.92	0.00 [0.00-1.28]
Woody perennials							
Willow	0.00 [0.00-1.92]	0.00 [0.00-3.84]	0.00 [0.00-3.84]	0.00 [0.00-0.77]	0.00 [0.00-1.92]	0.00 [0.00-1.92]	0.33 [0.06-1.89]

* A sub-group of three forbs: Glycyrrhiza, Apocynum, and Asclepias.

Table 5. Summary of substrates and vegetation coverage and density for Tepee, Transects 4 and 5 (Yampa) sampling location.

Substrate: mean percent [95% confidence intervals]

Elevation zone	I	II	III	IV	III	II	I
Fines	5.00	0.00	0.00	0.00	2.94	10.00	0.00
	[0.88-23.61]	[0.00-11.35]	[0.00-2.50]	[0.00-0.58]	[1.26-6.70]	[4.93 19.23]	[0.00-7.13]
Sand	5.00	26.67	95.33	50.91	80.00	35.71	0.00
	[0.89-23.61]	[14.18-44.44]	[90.68-97.72]	[47.10-54.71]	[73.36-85.32]	[25.50-47.41]	[0.00-7.13]
Rock	90.00	73.33	4.67	46.82	18.82	54.28	0.00
	[69.90-97.21]	[55.56-85.82]	[2.28-9.32]	[43.04-50.63]	[13.66-25.36]	[42.70-65.42]	[0.00-7.13]
Litter	0.00	0.00	0.00	0.76	0.59	0.00	0.00
	[0.00-16.11]	[0.00-11.35]	[0.00-2.50]	[0.32-1.76]	[0.10-3.26]	[0.00 5.20]	[0.00-7.13]
Log		N	O	N	E		

Vegetative cover: mean percent absolute cover [95% confidence intervals]

Elevation zone	I	II	III	IV	III	II	I
Total cover	0.00	6.67	10.67	34.24	32.35	22.86	26.00
	[0.00-16.11]	[1.85-21.32]	[6.67-16.62]	[30.72-37.94]	[25.78-39.71]	[14.59-33.95]	[15.87-39.55]
Horsetails	0.00	0.00	0.00	1.52	8.24	8.57	14.00
	[0.00-16.11]	[0.00-11.35]	[0.00-2.50]	[0.82] 2.77]	[4.97-13.35]	[3.99-17.46]	[6.95-26.18]
Sedges-Rushes		N	O	N	E		
Grasses	0.00	0.00	0.00	0.76	0.59	0.00	0.00
	[0.00-16.11]	[0.00-11.35]	[0.00-2.50]	[0.32-1.76]	[0.10-3.26]	[0.00-5.20]	[0.00-7.13]
Forbs	0.00	0.00	0.00	3.03	1.76	4.29	0.00
	[0.00-16.11]	[0.00-11.35]	[0.00-2.50]	[1.97-4.63]	[0.60-5.06]	[1.47-11.86]	[0.00-7.13]
Woody perennials	0.00	6.67	10.67	29.39	24.71	11.43	12.00
	[0.00-16.11]	[1.85-21.32]	[6.67-16.62]	[26.05-32.98]	[18.83-31.70]	[5.91-20.96]	[5.62-23.80]
Willow	0.00	6.67	10.67	29.39	24.71	11.43	12.00
	[0.00-16.11]	[1.85-21.32]	[6.67-16.62]	[26.05-32.98]	[18.83-31.70]	[5.91-20.96]	[5.62-23.80]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

Table 5. continued

Vegetative Density: mean number of plants per square meter [95% confidence intervals]

Elevation zone	I	II	III	IV	III	II	I
Forbs (all)	11.00 [7.27-16.65]	0.00 [0.00-1.28]	0.00 [0.00-0.26]	7.88 [7.23-8.59]	9.76 [8.39-11.37]	39.57 [35.18-44.51]	79.80 [72.35-88.02]
G-A-A *	0.00 [0.00-1.92]	0.00 [0.00-1.28]	0.00 [0.00-0.26]	0.00 [0.00-0.06]	1.94 [1.38-2.73]	0.00 [0.00-0.55]	0.00 [0.00-0.77]
Woody perennials							
Willow	0.00 [0.00-0.17]	0.00 [0.00-0.12]	4.40 [4.08-4.73]	7.98 [7.78-8.19]	8.94 [8.52-9.38]	12.28 [10.52-13.67]	2.00 [1.76-2.24]
Cottonwood seedlings	0.00 [0.00-0.96]	0.00 [0.00-0.96]	0.00 [0.00 0.24]	0.00 [0.00-0.05]	1.16 [0.76-1.75]	1.22 [0.68-2.19]	0.00 [0.00-0.48]

Heavy vertical lines indicate significant (at 95% confidence) differences between adjacent zones.
* A sub-group of forbs: Glycyrrhiza, Apocynum, and Asclepias.

Table 6

Plant Species List: Tepee Rapids (Transects 3,4,5)

Horsetails	_Equisetum hyemale_ L. _Equisetum laevigatum_ A. Br.
Sedges & Rushes	cf. _Carex aquatilis_ Wahlenb. _Eleocharis_ sp.
Grasses	_Agropyron smithii_ Rydb. _Agropyron trachycaulum_ (Link) Malte
Forbs	_Apocynum cannabinum_ var. _glaberrimum_ A. DC. _Franseria discolor_ Nutt. _Glycyrrhiza lepidota_ Pursh _Melilotus officinalis_ (L.) Lam. _Potentilla anserina_ L. var. _anserina_ _Xanthium_ sp.
Woody Perennials	_Salix exigua_ Nutt.

Tepee Rapids

Three transects were run across the gravel island above Tepee Rapids, (Fig. 14, Table 4), one at the foot (Transect 3, downstream end) and two through the central part of the island (Transects 4 and 5). The foot of the island was distinctly different from the rest, and therefore the data from that section are presented separately.

A large sand deposit dominated the substrate at the lower end of the island (Table 5). Total plant coverage was low. *Glycyrrhiza lepidota* and *Apocynum cannabinum* were the dominant species on the sand, while sedges and rushes, particularly *Eleocharis* (spike-rush), dominated the shoreline. Sedge and rush cover was significantly higher on the inner shoreline where the effects of scouring were not as great (Table 6).

The central section of the island (Fig. 15) was dominated by sandbar willow (*Salix exigua*). Maximum coverage of this species was attained on the highest ground of the island and coverage was higher on the inner slope than the other, again possibly reflecting less scouring on the inner slope.

Fig. 15. This photo shows the top of the gravel island which was sampled above Tepee Rapids. The dominant species is sandbar willow.

Haystack Rock

The sampling site at Haystack Rock was heavily vegetated (Fig. 16, Tables 7 and 8). A dense stand of *Glycyrrhiza lepidota* mixed with *Equisteum* dominated the sandy floodzone area. Young willow and tamarisk plants were present well into the floodzone, while young cottonwoods were found just below the floodline. The willows and cottonwoods in the floodzone all had stem diameters of less than 1 cm, while the largest tamarisk had a maximum stem diameter of less than 4 cm. Cottonwood seedlings were also found throughout the floodzone.

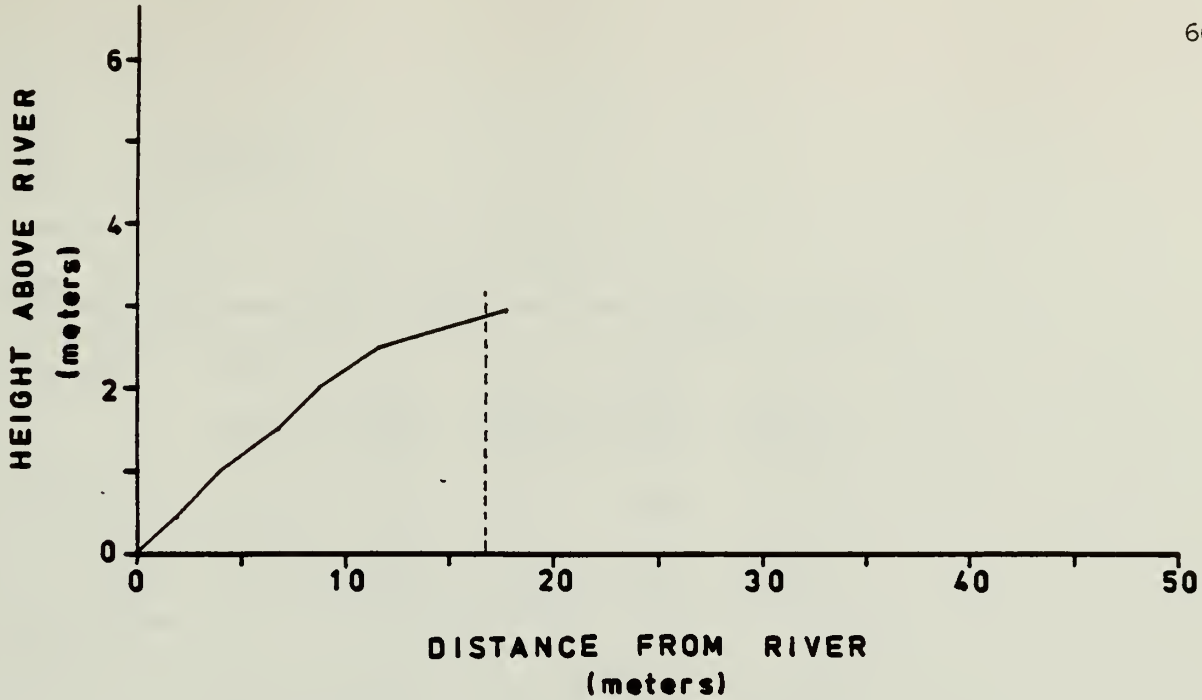


Fig. 16. Representative relief profile for Haystack sampling location. Dashed line represents the floodline.

Table 7. Summary of substrates and vegetation coverage and density for Haystack (Yampa River) sampling location.

Substrate: mean percent [95% confidence interval]

Elevational zone	I	II	III	IV	V
Fines		N O	N E		
Sand	88.00	100.00	98.57	90.83	92.31
	[81.83-92.27]	[96.30-100.00]	[94.94-99.61]	[84.33-94.80]	[86.42-95.77]
Rock	12.00	0.00	0.00	0.00	0.00
	[7.73-18.17]	[0.00-3.70]	[0.00-2.67]	[0.00-3.10]	[0.00-2.87]
Litter	0.00	0.00	0.00	0.00	2.31
	[0.00-2.50]	[0.00-3.70]	[0.00-2.67]	[0.00-3.10]	[0.79-6.56]
Log	0.00	0.00	1.43	9.17	5.39
	[0.00-2.50]	[0.00-3.70]	[0.39-5.06]	[5.20-15.67]	[2.63-10.70]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

Table 7. (continued)

Elevational zone	I	II	III	IV	V
Vegetative Cover: mean percent absolute cover [95% confidence intervals]					
Total Cover	20.00 [14.38-27.11]	23.00 [15.84-32.15]	25.71 [19.19-33.53]	55.83 [46.91-64.40]	46.92 [38.56-55.46]
Horsetails	2.67 [1.04-6.65]	4.00 [1.57-9.84]	7.86 [4.44-13.52]	17.50 [11.74-25.27]	7.69 [4.23-13.58]
Sedges & Rushes		N	O	N	E
Grasses	0.00 [0.00-2.50]	0.00 [0.00-3.70]	0.71 [0.13-3.93]	13.33 [8.38-20.56]	7.69 [4.23-13.58]
Forbs (all)	7.33 [4.14-12.65]	0.00 [0.00-3.70]	9.29 [5.51-15.24]	35.00 [27.05-43.88]	10.00 [5.94-16.36]
G-A-A *	1.33 [0.37-4.73]	0.00 [0.00-3.70]	7.86 [4.44-13.52]	29.17 [21.78-37.84]	3.08 [1.20-7.64]
Woody perennials (all)	10.67 [6.67-16.62]	23.75 [15.77-34.14]	10.00 [5.68-17.02]	5.00 [2.16-11.17]	62.50 [47.04-75.78]
Willow	7.33 [4.14-12.65]	17.00 [10.89-25.55]	7.86 [4.44-13.52]	2.50 [0.85-7.09]	15.38 [10.19-22.57]
Tamarisk	0.00 [0.00-2.50]	2.00 [0.55-7.00]	0.00 [0.00-2.67]	0.00 [0.00-3.10]	0.00 [0.00-2.87]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

* A sub-group of forbs: Glycyrrhiza, Apocynum, and Asclepias.

Table 8.

Plant Species List: Haystack (Transects 6,7,8)

Horsetails	*Equisetum arvense* L. *Equisetum hyemale* L. *Equisetum laevigatum* A. Br.
Grasses	*Agropyron smithii* Rydb. *Agropyron trachycaulum* (Link) Malte *Distichlis stricta* (Torr.) Rydb.
Forbs	*Chrysopsis villosa* (Pursh) Nutt. *Glycyrrhiza lepidota* Pursh *Iva axillaris* Pursh *Polygonum amphibium* L. *Potentilla anserina* L. var. *anserina* *Rosa* sp. *Xanthium* sp.
Woody Perennials	*Populus wislizenii* (S. Wats.) Sarg. *Rhus trilobata* Nutt. ex. T. & G. *Salix exigua* Nutt. *Tamarix pentandra* Pall.

Big Joe Rapids

The most heavily vegetated site sampled on the Yampa was at Big Joe Rapids (Tables 9 and 10). The outwashed debris from Starvation Draw, which forms the rapids, constricts the river channel and forms a pool of quiet water above it. The sampling site was located on the right bank of this pool, where sediments dropped by the slowed water form a long, terraced sand beach with bars and flats of finer sediments at the base (Figs. 17 and 18).

Very high total coverage values reflect the lack of scouring action at this site. The dominant forb species near the water's edge was *Polygonum amphibium* (Fig. 19). This remarkable plant grows from perennial rootstocks while still submerged. As the water level recedes, it changes its growth habit from an aquatic to a terrestrial plant.

Sedges and rushes were also important components of the vegetation in the lower part of the floodzone. Higher, *Equisetum arvense* and *Apocynum cannabinum* were dominant herbaceous species, occurring with willow and tamarisk. Willow was notably lower in the floodzone than tamarisk.

Tamarisk seedlings were noted in the transects at this site and were abundant (1200 per square meter) in Zones III and VI. Cottonwood seedlings were also found here, and were most common.

A dense stand of large (3 to 4 m tall) tamarisk plants formed a gallery on the high terrace, above the floodline. Litter from these plants completely covered the ground beneath them, apparently inhibiting growth of understory plants. Behind this gallery was a thicket of squawbush.

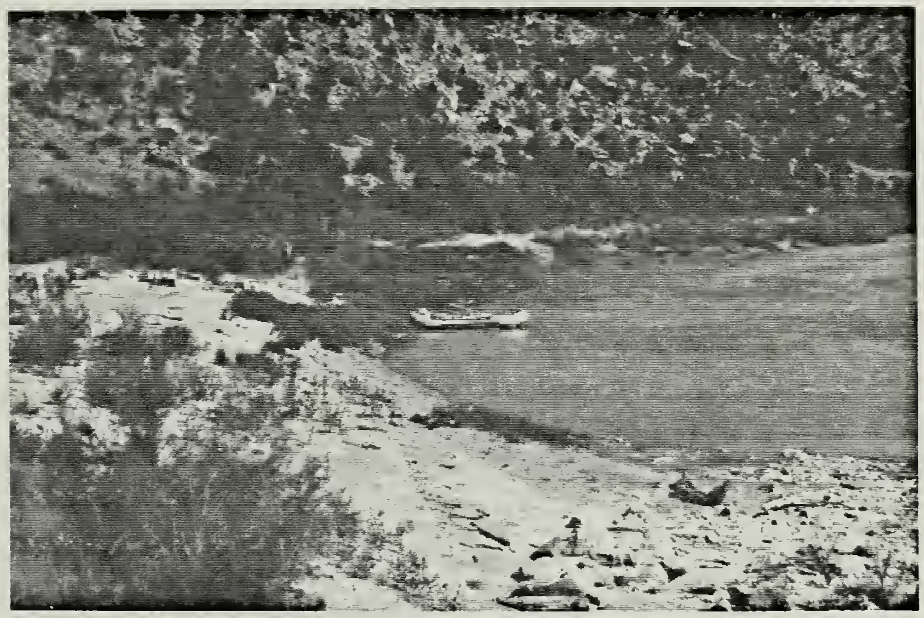


Fig. 17. The sampling location at Big Joe Rapids exhibited lush vegetation in the floodzone, primarily Carex aquatilis and Polygonum amphibium. The high terrace is topped by a dense stand of large tamarisk.

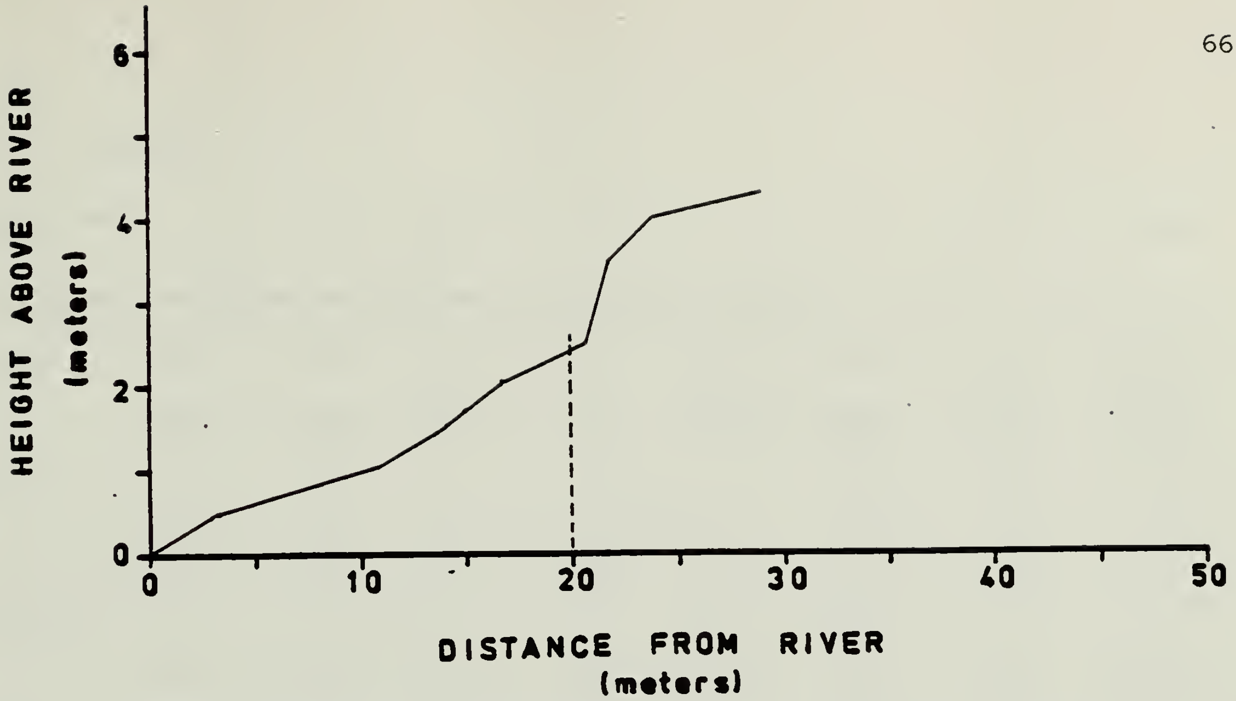


Fig. 18. Representative relief profile for Big Joe sampling location. Dashed line represents the floodline.

Table 9. Summary of substrates and vegetation coverage and density for Big Joe (Yampa River) sampling locatio

Substrate: mean percent [95% confidence intervals]

Elevational zones	I	II	III	IV	V	VI	XII	XIII
Fines	45.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[34.58-55.88]	[0.00-2.87]	[0.00-5.20]	[0.00-4.58]	[0.00-2.34]	[0.00-7.13]	[0.00-27.75]	[0.00-16.11]
Sand	52.50	100.00	100.00	86.25	53.75	0.00	0.00	0.00
	[41.70-63.07]	[97.13-100.00]	[94.80-100.00]	[77.04-92.14]	[46.03-61.30]	[0.00-7.13]	[0.00-27.75]	[0.00-16.11]
Rock		N	O	N	E			
Litter	0.00	0.00	0.00	11.25	41.88	100.00	90.00	80.00
	[0.00-4.58]	[0.00-2.88]	[0.00-5.20]	[3.03-20.02]	[34.51-49.62]	[92.87-100.00]	[59.59-98.21]	[59.40-91.93]
Log	2.50	0.00	0.00	2.50	4.38	0.00	10.00	20.00
	[0.69-8.66]	[0.00-2.87]	[0.00-5.20]	[0.69-8.66]	[2.14-8.75]	[0.00-7.13]	[1.79-40.41]	[8.07-41.60]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

Table 9. (continued)

Vegetative cover: mean percent absolute cover [95% confidence intervals]

Elevational zones	I	II	III	IV	V	VI	XII	XIII
Total Cover	82.50 [72.74-89.28]	81.54 [74.00-87.27]	78.57 [67.61-86.56]	73.75 [63.19-82.14]	69.38 [61.85-76.00]	90.00 [78.64-95.65]	100.00 [72.24-100.00]	100.00 [83.84-100.00]
Horsetails	7.50 [3.48-15.41]	16.92 [11.45-24.29]	30.00 [20.54-41.54]	28.75 [19.99-39.46]	4.38 [2.14-8.75]	0.00 [0.00-7.13]	0.00 [0.00-27.75]	0.00 [0.00-16.11]
Sedges-Rushes	48.75 [38.11-59.50]	34.62 [26.99-43.13]	0.00 [0.00-5.20]	0.00 [0.00-4.58]	0.00 [0.00-2.34]	0.00 [0.00-7.13]	0.00 [0.00-27.75]	0.00 [0.00-16.11]
Forbs (all)	38.75 [28.83-49.70]	23.84 [17.34-31.85]	40.00 [29.34-51.70]	22.50 [14.73-32.78]	29.38 [22.87-36.85]	78.00 [64.76-87.24]	30.00 [10.78-60.32]	50.00 [29.93-70.07]
G-A-A*	0.00 [0.00-4.50]	0.77 [0.14-4.23]	0.00 [0.00-5.20]	22.50 [14.73-32.78]	20.62 [15.08-27.55]	78.00 [64.76-87.24]	0.00 [0.00-27.75]	0.00 [0.00-16.11]
Woody perennials (all)	0.00 [0.00-4.58]	21.54 [15.34-29.37]	31.43 [21.76-43.02]	40.00 [29.96-50.95]	34.38 [27.46-42.02]	64.00 [56.44-69.12]	100.00 [76.54-100.00]	85.00 [63.67-96.11]
Willow	0.00 [0.00-4.58]	21.54 [15.34-29.37]	30.00 [20.54-41.54]	11.25 [6.03-20.02]	0.00 [0.00-2.34]	0.00 [0.00-7.13]	0.00 [0.00-27.75]	0.00 [0.00-16.11]
Tamarisk	0.00 [0.00-4.58]	0.00 [0.00-2.87]	1.43 [0.25-7.66]	28.75 [19.99-39.46]	37.50 [30.38-45.21]	64.00 [50.14-75.86]	100.00 [72.25-100.00]	85.00 [63.96-94.76]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

* A sub-group of forbs: Glycyrrhiza, Apocynum, and Asclepias.

Table 9. (continued)

Vegetative density: mean number of plants per square meter [95% confidence intervals]

Elevational zones	I	II	III	IV	V	VI	XII	XIII
Forbs	130.37	82.77	91.75	88.75	33.94	15.40	11.00	11.00
	[122.70-138.53]	[77.97-87.86]	[85.03-99.94]	[82.46-95.52]	[31.20-36.91]	[12.32-19.24]	[6.14-19.70]	[7.27-16.65]
G-A-A*	0.00	0.00	0.00	15.25	6.19	2.20	0.00	0.00
	[0.00-0.48]	[0.00-0.30]	[0.00-0.55]	[12.77-18.21]	[5.08-7.53]	[1.23-3.94]	[0.00-3.84]	[0.00-1.92]
Woody perennials								
Willow	0.00	3.69	1.42	0.49	0.06	0.00	0.00	0.00
	[0.00-0.04]	[3.39-4.01]	[1.17-1.71]	[0.37-0.66]	[0.03-0.11]	[0.00-0.07]	[0.00-0.34]	[0.00-0.17]
Tamarisk seedling	0.00	609.62	1225.57	1189.00	2.75	0.00	0.00	0.00
	[0.00-0.48]	[596.36-623.16]	[1199.90-1251.79]	[1165.35-1213.13]	[2.05-3.69]	[0.00-0.77]	[0.00-3.84]	[0.00-1.92]
mature	0.00	0.00	0.00	5.13	2.56	9.60	0.00	0.00
	[0.00-0.48]	[0.00-0.30]	[0.00-0.55]	[3.78-6.95]	[1.89-3.48]	[7.24-12.73]	[0.00-3.84]	[0.00-1.92]
Cottonwood seedlings	0.00	0.00	0.00	13.75	0.69	0.00	0.00	0.00
	[0.00-0.48]	[0.00-0.30]	[0.00-0.55]	[11.41-16.57]	[0.38-1.23]	[0.00-0.77]	[0.00-3.84]	[0.00-1.92]
Shrubs	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00
	[0.00-0.48]	[0.00-0.30]	[0.00-0.55]	[0.00-0.48]	[0.06-0.55]	[0.00-0.77]	[0.00-3.84]	[0.00-1.92]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

* A sub-group of forbs: Glycyrrhiza, Apocynum, and Asclepias.

Table 10.

Plant Species List: Big Joe Rapids (Transects 9, 10, 11)

Horsetails	Equisteum arvense L. Equisteum hyemale L. Equisetum laevigatum A. Br.
Sedges & Rushes	cf. Carex aquatilis Wahlenb. Eleocharis sp. Juncus sp.
Grasses	Distichlis stricta (Torr.) Rydb.
Forbs	Apocynum cannabinum var. glaberrimum A. DC. Glycyrrhiza lepidota Pursh Gnaphalium palustre Nutt. Iva axillaris Pursh Medicago sativa L. Oenothera sp. Polygonum amphibium L.
Woody Perennials	Populus sp. Rhus trilobata Nutt. ex. T. & G. Salix exigua Nutt. Tamarix pentandra Pall.

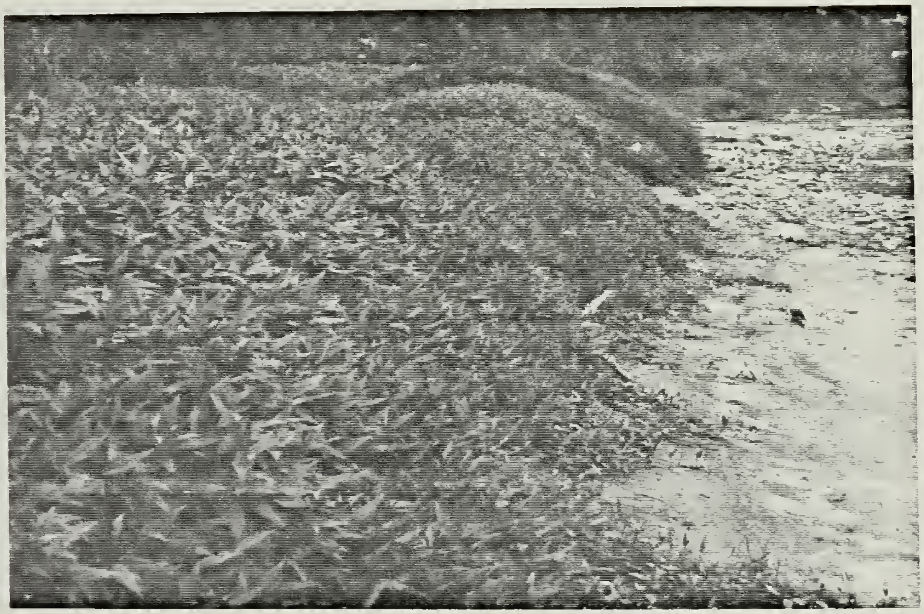


Fig. 19. Polygonum amphibium above Big Joe Rapids. Note the stems leading into the water.

Mather's Hole

Two geomorphic situations were sampled at Mather's Hole, a sand beach (Transects 12 and 13) and a gravel bar (Transect 14). The beach had a long, flat floodzone which was gravelly at the water's edge and distinctly terraced at the upper end (Fig. 20). Dominant species in the floodzone included *Franseria discolor* (bursage), *Distichlis stricta* (saltgrass), *Spartina pectinata* (cordgrass), and *Carex aquatilis* (Tables 11 and 12). Willow occurred in Zone I of this site. Tamarisk was the dominant woody species of Zones IV and V, being represented by large individuals in the latter zone. Tamarisk seedlings were very dense (2200 per square meter) near the floodline.

The top of the gravel bar at Mather's Hole extended above floodline and had a more xeric vegetation with high amounts of litter accumulation (Table 13). The outer slope of the bar was relatively bare (Fig. 21), with forbs and *Equisetum* making up most of the plant coverage. Plant coverage was fairly high in the bottom of the channel separating the bar from the bank. Dominant species in the channel were willow and *Apocynum cannabinum*. A few cottonwood saplings also occurred here as well as several willow seedlings.

The bank slope was heavily vegetated with grasses and forbs. *Distichlis stricta* was the dominant grass, extending below the floodline.

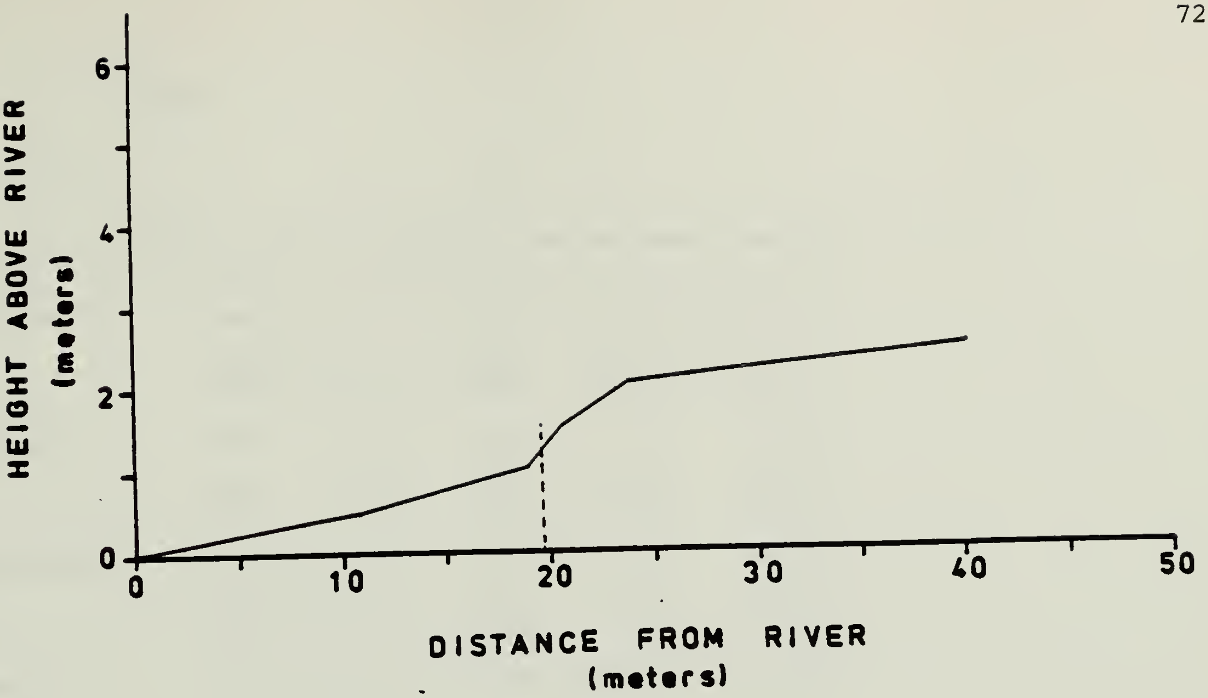


Fig. 20. Representative relief profile for Mather's Hole sampling location. Dashed line represents the floodline.

Table 11. Summary of substrates and vegetation coverage and density for Mather's Hole, Transects 12 and 13 (Yampa Rive
sampling location.

Vegetation zones	I	II	III	IV	V
Substrate: mean percent [95% confidence intervals]					
Fines	47.06 [41.82-52.37]	30.00 [22.23-39.12]	0.00 [0.00-7.13]	0.00 [0.00-7.13]	0.00 [0.00-1.26]
Sand	15.59 [12.12-19.82]	44.54 [35.60-53.86]	92.00 [81.16-96.84]	34.00 [22.44-47.84]	4.33 [2.55-7.27]
Rock	36.47 [31.53-41.71]	25.45 [18.24-34.33]	0.00 [0.00-7.13]	0.00 [0.00-7.13]	0.00 [0.00-1.26]
Litter	0.88 [0.30-2.56]	0.00 [0.00-3.37]	8.00 [3.16-18.84]	66.00 [52.16-77.56]	95.33 [92.32-97.20]
Log	0.00 [0.00-1.12]	0.00 [0.00-3.37]	0.00 [0.00-7.13]	0.00 [0.00-7.13]	0.33 [0.06-1.86]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

Table 11. (continued)

Elevation zone	I	II	III	IV	V

Vegetative cover: mean percent absolute cover [95% confidence intervals]

	I	II	III	IV	V
Total cover	2.94 [1.60-5.33]	32.73 [24.67-41.95]	36.00 [24.14-49.86]	56.00 [42.31-68.84]	86.67 [82.35-90.05]
Horsetails	0.88 [0.30-2.56]	3.64 [1.42-8.98]	0.00 [0.00-7.13]	8.00 [3.16-18.84]	6.67 [4.36-10.07]
Sedges-Rushes	0.88 [0.30-2.56]	7.27 [3.73-13.70]	10.00 [4.35-21.36]	0.00 [0.00-7.13]	0.00 [0.00-1.26]
Grasses	0.00 [0.00-1.12]	10.00 [5.68-17.02]	2.00 [0.35-10.49]	24.00 [14.30-37.41]	40.00 [34.62-45.64]
Forbs	0.88 [0.30-2.56]	10.00 [5.68-17.02]	14.00 [6.95-26.18]	12.00 [5.62-23.80]	30.67 [25.72-36.10]
Woody perennials (all)	0.29 [0.05-1.65]	2.73 [0.93-7.71]	6.00 [2.06-16.21]	24.00 [14.30-37.41]	33.00 [27.92-38.51]
Willow	0.29 [0.05-1.65]	0.00 [0.00-3.37]	0.00 [0.00-7.13]	0.00 [0.00-7.13]	0.00 [0.00-1.26]
Tamarisk	0.00 [0.00-1.12]	2.72 [0.93-7.71]	6.00 [2.06-16.21]	24.00 [14.30-37.41]	22.67 [18.29-27.75]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

Table 11. continued

Elevational zones

Vegetative density: mean number of plants per square meter [95% confidence intervals]

Forbs	10.76 [9.72-11.93]	66.55 [61.90-71.54]	8.80 [6.56-11.81]	59.80 [53.40-66.97]	33.63 [31.62-35.77]
G-A-A *	0.00 [0.00-0.11]	1.00 [0.56-1.79]	0.00 [0.00-0.77]	0.00 [0.00-0.77]	0.00 [0.00-0.13]
Cottonwood seedling	0.32 [0.18-0.58]	0.00 [0.00-0.35]	0.00 [0.00-0.77]	0.00 [0.00-0.77]	0.00 [0.00-0.13]
Tamarisk seedling	18.26 [16.88-19.76]	825.36 [808.58-842.49]	2233.20 [2192.30-2274.86]	181.80 [170.37-194.00]	0.00 [0.00-0.13]
Willow	0.14 [0.11-0.19]	0.09 [0.02-0.51]	0.00 [0.00-0.77]	0.20 [0.11-0.35]	0.00 [0.00-0.13]
Tamarisk mature	0.00 [0.00-0.11]	0.09 [0.02-0.51]	1.00 [0.43-2.34]	3.80 [2.43-5.93]	1.30 [0.95-1.78]

Heavy vertical lines indicate significant difference(at 95% confidence) between adjacent zones.
* A sub-group of forbs: Glycyrrhiza, Apocynum, and Asclepias.

Table 12.

Plant Species List: Mather Hole (Transects 12, 13, 14)

Horsetails	Equisetum arvense L. Equisetum hyemale L. Equisetum laevigatum A. Br.
Sedges & Rushes	cf. Carex aquatilis Wahlenb. cf. Eleocharis sp. Juncus sp. Juncus bufonius L.
Grasses	Agropyron smithii Rydb. Agrostis alba L. Distichlis stricta (Torr.) Rydb. Panicum sp. Poa pratensis L. Spartina pectinata Link Sporobolus cryptandrus (Torr.) A. Gray
Forbs	Amaranthus palmeri Wats. Apocynum cannabinum var. glaberrimum A. DC. Aster hesperinus Gray var. hesperinus cf. Chenopodium fremontii Wats. Chenopodium leptophyllum Nutt. Chrysopsis villosa (Pursh) Nutt. Franseria discolor Nutt. Gnaphalium palustre Nutt. Grindelia squarrosa (Pursh) Dunal var. squarrosa Iva axillaris Pursh Medicago lupilina L. Medicago sativa L. Mentha arvensis L. Oxybaphus lanceolatus (Rydb.) Standl. Plantago major L. Polygonum amphibium L. Polygonum lapathifolium L. Potentilla anserina L. var. anserina Rumex sp. Selloa glutinosa Spreng. cf. Sonchus asper (L.) Hill Verbascum thapsus L. Xanthium commune Britt. Xanthium italicum Moretti
Woody Perennials	Acer negundo L. Artemisia ludoviciana Nutt. Populus sp. Populus wislizeni (S. Wats.) Sarg. Salix exigua Nutt. Tamarix pentandra Pall.

Table 13. Summary of substrates and vegetation coverage and density for Mather's Hole, Transect 14 (Yampa River) sampling location.

Substrate: mean percent [95% confidence intervals]

Elevational zone	I	II	III	IV	V	VI	VII	VIII	VII	VI	V	IV
Fines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-16.11-	[0.00-16.11-	[0.00-11.35-	[0.00-16.11]	[0.00-16.11]	[0.00-27.75]	[0.00-16.11]	[0.00-11.35]	[0.00-27.75]	[0.00-27.75]	[0.00-16.11]	[0.00-11.35]
Sand	20.00	5.00	16.67	100.00	100.00	90.00	60.00	16.67	80.00	80.00	70.00	43.33
	[8.07-41.60]	[0.89-23.61]	[7.34-33.56]	[83.89-100.00]	[83.89-100.00]	[59.59-98.21]	[38.66-78.12]	[7.34-33.56]	[49.02-94.33]	[49.02-94.33]	[48.11-85.45]	[27.38-60.80]
Rock	80.00	95.00	83.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.00	56.67
	[58.40-91.93]	[76.39-99.11]	[66.43-92.66]	[0.00-16.11]	[0.00-16.11]	[0.00-27.75]	[0.00-16.11]	[0.00-11.35]	[0.00-27.75]	[0.00 27.75]	[14.55-51.89]	[39.20-72.62]
Litter	0.00	0.00	0.00	0.00	0.00	10.00	40.00	83.33	20.00	0.00	0.00	0.00
	[0.00-16.11]	[0.00-16.11]	[0.00-11.35]	[0.00-16.11]	[0.00-16.11]	[1.79-40.41]	[21.88-61.34]	[66.44-92.66]	[5.67-50.98]	[0.00-27.75]	[0.00-16.11]	[0.00-11.35]
Log	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00
	[0.00-16.11]	[0.00-16.11]	[0.00-11.35]	[0.00-16.11]	[0.00-16.11]	[0.00-27.75]	[0.00-16.11]	[0.00-11.35]	[0.00-27.75]	[5.67-50.98]	[0.00-16.11]	[0.00-11.35]

Elevational zone	III	II	I	II	III	IV	V	VI	VII	IX	X
Fines	0.00	0.00	1.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-16.11]	[0.00-11.35]	[0.71-4.58]	[0.00-16.11]	[0.00-11.35]	[0.00-1.88]	[0.00-16.11	[0.00-27.75]	[0.00-27.75]	[0.00-27.75]	[0.00-27.75]
Sand	75.00	93.33	18.18	100.00	96.67	54.50	85.00	0.00	10.00	10.00	0.00
	[53.13-88.81]	[78.68-98.15]	[13.65-23.81]	[83.89-100.00]	[83.33-99.41]	[47.58-61.25]	[63.96-94.76]	[0.00-27.75]	[1.79-40.41]	[1.79-40.41]	[0.00-27.75]
Rock	25.00	6.67	75.46	0.00	0.00	43.50	0.00	0.00	0.00	0.00	0.00
	[11.19-46.87]	[1.85-21.32]	[69.36-80.67]	[0.00-16.11]	[0.00-11.35]	[36.82-50.43]	[0.00-16.11]	[0.00-27.75]	[0.00-27.75]	[0.00-27.75]	[0.00-27.75]
Litter	0.00	0.00	4.09	0.00	3.33	2.00	15.00	90.00	90.00	90.00	100.00
	[0.00-16.11]	[0.00-11.35]	[2.17-7.59]	[0.00-16.11]	[0.59-16.67]	[0.78-5.03]	[5.24-36.04]	[59.59-98.21]	[59.59-98.21]	[59.59-98.21]	[72.25-100.00]
Log	0.00	0.00	0.46	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00
	[0.00-16.11]	[0.00-11.35]	[0.08-2.53]	[0.00-16.11]	[0.00-11.35]	[0.00-1.88]	[0.00-16.11]	[1.79-40.41]	[0.00-27.75]	[0.00-27.75]	[0.00-27.75]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

Table 13. (continued).

Vegetative cover: mean percent absolute cover [95% confidence intervals]

Elevational zone	I	II	III	IV	V	VI	VII	VIII	VII	VI	V	IV
Total cover	0.00	5.00	6.67	45.00	50.00	50.00	90.00	82.33	0.00	0.00	5.00	3.33
	[0.00-16.11]	[0.89-23.61]	[1.85-21.32]	[25.82-65.79]	[29.93-70.07]	[23.66-76.34]	[69.90-97.21]	[66.43-92.66]	[0.00-27.75]	[0.00-27.75]	[0.89-23.61]	[0.59-16.67]
Horsetails	0.00	0.00	0.00	20.00	20.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-16.11]	[0.00-16.11]	[0.00-11.35]	[8.07-41.60]	[8.07-41.60]	[5.67-50.98]	[0.00-16.11]	[0.00-11.35]	[0.00-27.75]	[0.00-27.75]	[0.00-16.11]	[0.00-11.35]
Sedges-Rushes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00
	[0.00-16.11]	[0.00-16.11]	[0.00-11.35]	[0.00-16.11]	[0.00-16.11]	[0.00-27.75]	[0.00-16.11]	[0.00-11.35]	[0.00-27.75]	[0.00-27.75]	[0.89-23.61]	[0.00-11.35]
Forbs (all)	0.00	5.00	6.67	35.00	45.00	30.00	35.00	56.67	0.00	0.00	0.00	3.33
	[0.00-16.11]	[0.89-23.61]	[1.85-21.32]	[18.12-56.71]	[25.82-65.79]	[10.78-60.32]	[18.12-56.71]	[39.20-72.62]	[0.00-27.75]	[0.00-27.75]	[0.00-16.11]	[0.59-16.67]
G-A-A*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-16.11]	[0.00-16.11]	[0.00-11.35]	[0.00-16.11]	[0.00-16.11]	[0.00-27.75]	[0.00-16.11]	[0.00-11.35]	[0.00-27.75]	[0.00-27.75]	[0.00-16.11]	[0.00-11.35]
Woody perennials (willow)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-16.11]	[0.00-16.11]	[0.00-11.35]	[0.00-16.11]	[0.00-16.11]	[0.00-27.75]	[0.00-16.11]	[0.00-11.35]	[0.00-27.75]	[0.00-27.75]	[0.00-16.11]	[0.00-11.35]

Elevational zone	III	II	I	II	III	IV	V	VI	VII	IX	X
Total cover	0.00	16.67	15.91	45.00	3.33	35.50	80.00	100.00	30.00	30.00	20.00
	[0.00-16.11]	[7.34-33.56]	[11.67-21.32]	[25.82-65.79]	[0.59-16.67]	[29.20-42.35]	[58.40-91.93]	[72.25-100.00]	[10.78-60.32]	[10.78-60.32]	[5.67-11.29]
Horsetails	0.00	3.33	7.73	5.00	3.33	1.50	0.00	0.00	0.00	0.00	0.00
	[0.00-16.11]	[0.59-16.67]	[4.88-12.02]	[0.89-23.61]	[0.59-16.67]	[0.51-4.32]	[0.00-16.11]	[0.00-27.75]	[0.00-27.75]	[0.00-27.75]	[0.00-27.75]
Sedges-Rushes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-16.11]	[0.00-11.35]	[0.00-16.11]	[0.00-16.11]	[0.00-11.35]	[0.00-1.89]	[0.00-16.11]	[0.00-27.75]	[0.00-27.75]	[0.00-27.75]	[0.00-27.75]
Forbs (all)	0.00	10.00	6.36	20.00	23.33	4.00	40.00	20.00	0.00	0.00	0.00
	[0.00-16.11]	[3.46-25.62]	[3.83-10.40]	[8.07-41.60]	[11.79-40.92]	[2.04-7.69]	[21.88-61.34]	[5.67-50.98]	[0.00-27.75]	[0.00-27.75]	[0.00-27.75]
G-A-A*	0.00	0.00	5.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-16.11]	[0.00-11.35]	[2.82-8.73]	[8.07-41.60]	[0.00-11.35]	[0.00-1.89]	[0.00-16.11]	[0.00-27.75]	[0.00-27.75]	[0.00-27.75]	[0.00-27.75]
Woody perennials (willow)	0.00	0.00	0.91	20.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00
	[0.00-16.11]	[0.00-11.35]	[0.25-3.25]	[8.07-4.60]	[0.00-11.35]	[0.09-1.89]	[0.00-16.11]	[0.00-27.75]	[0.00-27.75]	[0.00-27.75]	[0.00-27.75]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

* A sub-group of forbs: Glycyrrhiza, Apocynum, and Asclepias.

Table 13. (continued)

Vegetative density: mean number of plants per square meter [95% confidence intervals]

Elevational zone	I	II	III	IV	V	VI	VII	VIII	VII	VI
Forbs (all)	33.00	38.50	111.00	138.50	172.00	111.00	183.00	92.33	55.00	55.00
	[25.94-41.98]	[30.81-48.11]	[99.70-123.58]	[123.12-155.80]	[154.76-191.16]	[92.19-133.65]	[165.19-202.73]	[82.08-103.86]	[42.26-71.58]	[42.26-71.58]
G-A-A *	0.00	0.00	0.00	11.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-1.92]	[0.00-1.92]	[0.00-1.28]	[7.27-16.65]	[0.00-1.92]	[0.00-3.84]	[0.00-1.92]	[0.00-1.28]	[0.00-3.84]	[0.00-3.84]
Woody perennials Willow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-1.92]	[0.00-1.92]	[0.00-1.28]	[0.00-1.92]	[0.00-1.92]	[0.00-3.84]	[0.00-1.92]	[0.00-1.28]	[0.00-3.84]	[0.00-3.84]
Tamarisk seedling	0.00	0.00	0.00	11.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-1.92]	[0.00-1.92]	[0.00-1.28]	[7.27-16.65]	[0.00-1.92]	[0.00-3.84]	[0.00-1.92]	[0.00-1.28]	[0.00-3.84]	[0.00-3.84]
mature	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00
	[0.00-1.92]	[0.00-1.92]	[0.00-1.28]	[0.00-1.92]	[0.00-1.92]	[0.00-3.84]	[0.09-2.83]	[0.00-1.28]	[0.00-3.84]	[0.00-3.84]
Cottonwood mature	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-1.92]	[0.00-1.92]	[0.00-1.28]	[0.00-1.92]	[0.00-1.92]	[0.00-3.84]	[0.00-1.92]	[0.00-1.28]	[0.00-3.84]	[0.00-3.84]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

* A sub-group of forbs: Glycyrrhiza, Apocynum, and Asclepias.

able 13. (continued)

egetative density: mean number of plants per square meter [95% confidence intervals]

levational zone	V	IV	III	II	I	II	III	IV	V	VI	VII	IX	X
orbs (all)	44.00	18.33	0.00	148.00	33.77	49.50	14.67	68.80	94.00	122.00	11.00	33.00	0.00
	[35.72-54.20]	[14.09-23.86]	[0.00-1.92]	[134.86-162.42]	[31.43-36.29]	[40.66-60.26]	[10.93-19.69]	[65.26-72.53]	[81.49-108.43]	[102.19-145.65]	[6.14-19.70]	[23.50-46.34]	[0.00-3.84]
G-A-A *	0.00	11.00	0.00	0.00	16.14	33.00	0.00	1.10	0.00	0.00	0.00	0.00	0.00
	[0.00-1.92]	[7.83-15.45]	[0.00-1.92]	[0.00-1.28]	[14.54-17.90]	[25.94-41.98]	[0.00-1.28]	[0.73-1.67]	[0.00-1.92]	[0.00-3.84]	[0.00-3.84]	[0.00-3.84]	[0.00-3.84]
oody perennials Willow	0.00	0.00	0.00	0.00	3.73	3.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-1.92]	[0.00-1.28]	[0.00-1.92]	[0.00-1.28]	[3.49-3.98]	[3.22-4.88]	[0.00-1.28]	[0.00-0.19]	[0.00-1.92]	[0.00-3.84]	[0.00-3.84]	[0.00-3.84]	[0.00-3.84]
Tamarisk seedling	0.00	0.00	0.00	0.00	0.00	160.50	92.33	4.40	0.00	0.00	0.00	0.00	0.00
	[0.00-1.92]	[0.00-1.28]	[0.00-1.92]	[0.00-1.28]	[0.00-0.17]	[143.88-179.04]	[82.08-103.86]	[3.57-5.42]	[0.00-1.92]	[0.00-3.84]	[0.00-3.84]	[0.00-3.84]	[0.00-3.84]
mature	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-1.92]	[0.00-1.28]	[0.00-1.92]	[0.00-1.28]	[0.00-0.17]	[0.00-3.84]	[0.00-1.28]	[0.00-0.19]	[0.00-1.92]	[0.00-3.84]	[0.00-3.84]	[0.00-3.84]	[0.00-3.84]
Cottonwood	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-1.92]	[0.00-1.28]	[0.00-1.92]	[0.00-1.28]	[0.01-0.26]	[0.00-3.84]	[0.00-1.28]	[0.00-0.19]	[0.00-1.92]	[0.00-3.84]	[0.00-3.84]	[0.00-3.84]	[0.00-3.84]

Heavy vertical lines indicate significant (at 95% confidence) difference between zones.

* A sub-group of forbs: Glycyrrhiza, Apocynum, and Asclepias.

Laddie Park and Box Elder

The last two sites on the Yampa River, Laddie Park and Box Elder Campground, were both sand beaches and exhibited similar vegetational patterns (Fig. 22). Highest coverage occurred above the floodline at both sites, the floodzone being relatively bare (Figs. 23 and 24, Tables 14, 15, 16, and 17). Floodzone vegetation was dominated by *Carex aquatilis*, *Apocynum cannabinum*, and *Glycyrrhiza lepidota*. Grass coverage was highest above the floodline. Tamarisk occurred near the floodline at both sites. The willow at Laddie Park was again found lower in the floodzone than tamarisk. Tamarisk seedlings were found at both sites.

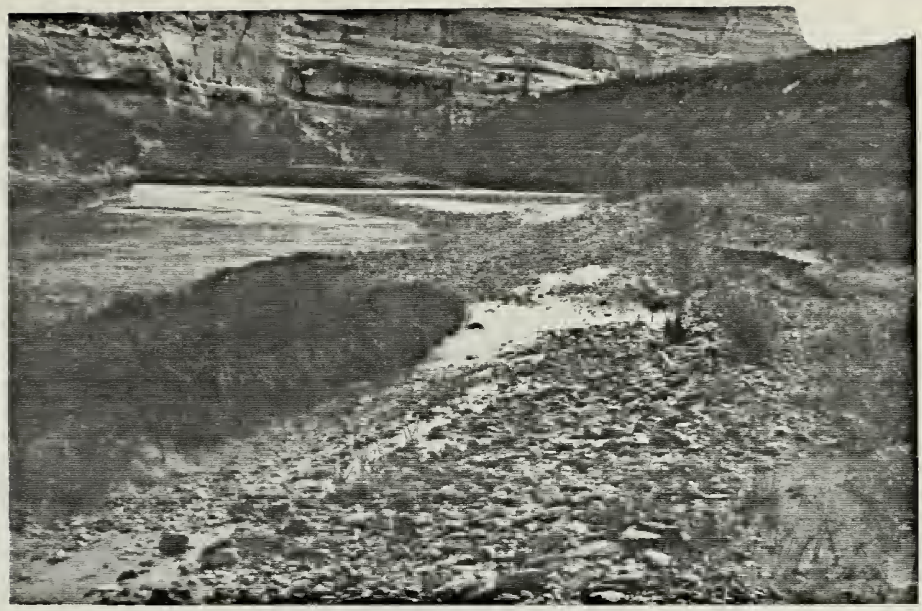


Fig. 21. This photo hows the outer slope of the gravel bar at Mather's Hole. To the right can be seen part of the upland type vegetation on top of the bar. In the left foreground is a patch of Carex aquatilis. Evidence was found here indicating clumps of Carex sod may be breaking off of the bank in the background and are then transported by the river to sites downstream.

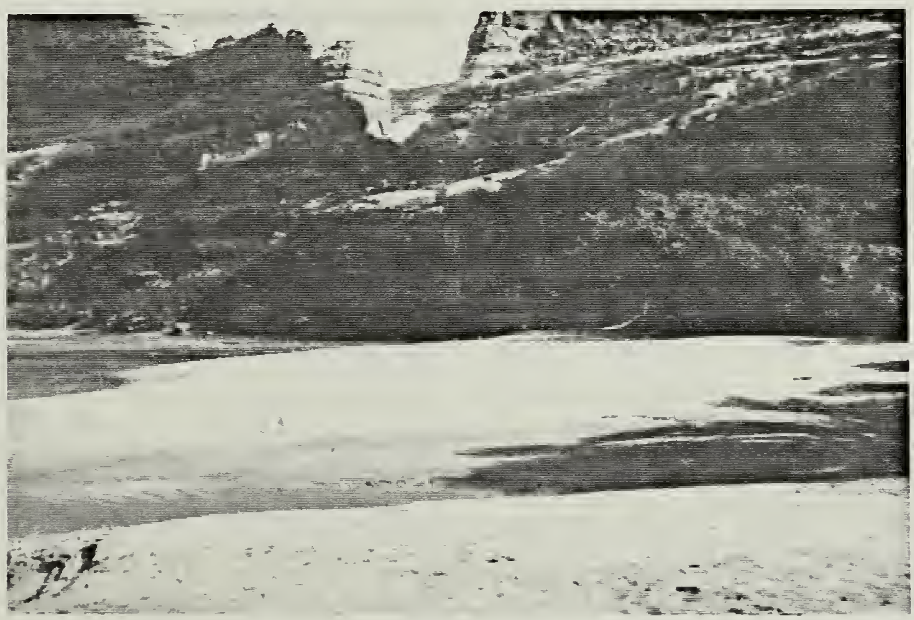


Fig. 22. The sampling site at Laddie Park had a generally similar appearance to that at Box Elder campground shown above. The long sandy beaches were essentially devoid of vegetation.

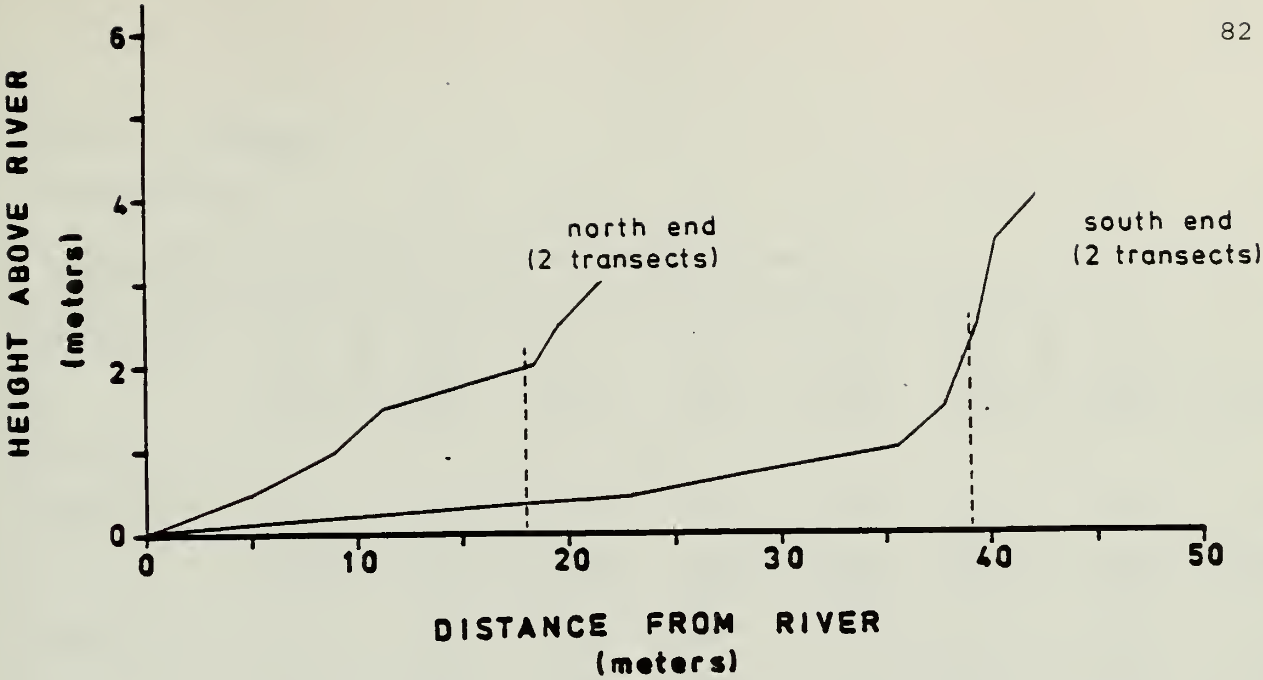


Fig. 23. Representative relief profile for Laddie Park sampling location. Dashed line represents the floodline.

Table 14. Summary of substrates and vegetation coverage and density for Laddie Park (Yampa River) sampling locatior

Substrate: mean percent [95% confidence intervals]

Elevational zone	I	II	III	IV	V	VI	VII	VIII
Fines	50.34	65.79	0.00	0.00	0.00	0.00	0.00	0.00
	[46.32-54.36]	[58.79-72.16]	[0.00-3.37]	[0.00-2.87]	[0.00-3.70]	[0.00-3.70]	[0.00-8.76]	[0.00-16.11]
Sand	34.75	26.84	61.12	76.15	83.00	55.00	20.00	5.00
	[31.01-38.68]	[21.05-33.56]	[52.49-70.35]	[68.15-82.66]	[74.45-89.10]	[45.25-64.38]	[10.50-34.75]	[0.89-23.61]
Rock	13.22	3.16	33.64	16.92	7.00	0.00	0.00	0.00
	[10.72-16.19]	[1.46-6.72]	[25.49-42.88]	[11.45-24.29]	[3.43-13.75]	[0.00-3.70]	[0.00-8.76]	[0.00-16.11]
Litter	1.70	4.21	2.73	0.77	9.00	45.00	75.00	95.00
	[0.92-3.09]	[2.15-8.09]	[0.93-7.71]	[0.14-4.23]	[4.81-16.22]	[35.62-54.75]	[59.81-85.81]	[76.39-99.11]
Log	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00
	[0.00-0.65]	[0.00-1.98]	[0.00-3.37]	[0.00-2.87]	[0.00-3.70]	[0.00-3.70]	[1.38-16.50]	[0.00-16.11]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

Table 14. (continued)

Vegetative Cover: mean absolute cover [95% confidence interval]

Elevational zone	I	II	III	IV	V	VI	VII	VIII
Total Cover	6.78	16.32	14.54	16.15	29.00	28.00	65.00	100.00
	[5.02-9.10]	[11.74-22.23]	[9.16-22.32]	[10.82-23.43]	[21.02-38.54]	[20.14-37.49]	[49.51-77.86]	[83.89-100.00]
Horsetails		N	O	N	E			
Sedges-Rushes	6.10	11.05	0.00	0.00	0.00	0.00	0.00	0.00
	[4.44-8.33]	[7.34-16.30]	[0.00-3.37]	[0.00-2.87]	[0.00-3.70]	[0.00-3.70]	[0.00-8.76]	[0.00-16.11]
Grasses	0.00	2.10	3.64	11.54	8.00	22.00	20.00	0.00
	[0.00-0.65]	[0.82-5.29]	[1.42-8.98]	[7.12-18.16]	[4.11-14.99]	[15.00-31.07]	[10.50-34.75]	[0.00-16.11]
Forbs (all)	0.17	4.74	9.09	3.85	2.00	7.00	30.00	35.00
	[0.03-0.95]	[2.51-8.76]	[5.01-15.93]	[1.65-8.69]	[0.55-7.00]	[3.43-13.75]	[18.08-45.43]	[18.12-56.71]
G-A-A *	0.00	4.21	7.27	2.31	0.00	0.00	0.00	0.00
	[0.00-0.65]	[2.15-8.09]	[3.73-13.70]	[0.79-6.56]	[0.00-3.70]	[0.00-3.70]	[0.00-8.76]	[0.00-16.11]
Woody perennials (all)	0.00	0.00	0.00	0.00	22.00	0.00	25.00	100.00
	[0.00-0.65]	[0.00-1.98]	[0.00-3.37]	[0.00-2.87]	[15.00-31.07]	[0.00-3.37]	[14.19-40.19]	[83.89-100.00]
Willow	0.17	0.00	1.82	0.00	2.00	0.00	0.00	0.00
	[0.03-0.95]	[0.00-1.98]	[0.50-6.39]	[0.00-2.87]	[0.55-7.00]	[0.00-3.70]	[0.00-8.76]	[0.00-16.11]
Tamarisk	0.00	0.00	0.00	0.00	20.00	0.00	25.00	100.00
	[0.00-0.65]	[0.00-1.98]	[0.00-3.37]	[0.00-2.87]	[13.34-28.88]	[0.00-3.70]	[14.19-40.19]	[83.89-100.00]

Heavy vertical lines indicate significant (at 95% confidence) diffference between adjacent zones.

* A sub-group of forbs: Glycyrrhiza, Apocynum, and Asclepias.

Table 14 . (continued)

Vegetative Density: mean number of plants per square meter [95% confidence interval]

Elevational zone	I	II	III	IV	V	VI	VII	VIII
Forbs (all)	2.81 [2.42-3.28]	5.21 [4.28-6.34]	24.09 [21.36-27.17]	21.31 [18.94-23.97]	15.40 [13.15-18.03]	27.70 [24.62-31.16]	5.50 [3.63-8.33]	16.50 [11.75-23.17]
G-A-A*	0.93 [0.72-1.21]	2.32 [1.73-3.11]	15.09 [12.96-17.57]	4.23 [3.25-5.51]	0.00 [0.00-0.38]	0.00 [0.00-0.38]	0.00 [0.00-0.96]	0.00 [0.00-1.92]
Woody perennials								
Willow	0.00 [0.00-0.07]	0.05 [0.03-0.09]	0.27 [0.19-0.38]	0.00 [0.00-0.30]	0.30 [0.21-0.42]	0.00 [0.00-0.38]	0.00 [0.00-0.96]	0.00 [0.00-1.92]
Tamarisk seedlings	0.00 [0.00-0.07]	0.00 [0.00-0.20]	327.91 [317.39-338.78]	67.38 [63.07-72.00]	18.80 [16.30-21.69]	0.00 [0.00-0.38]	0.00 [0.00-0.96]	0.00 [0.00-1.92]
mature	0.00 [0.00-0.07]	0.00 [0.00-0.20]	0.00 [0.00-0.35]	0.23 [0.08-0.68]	0.50 [0.21-1.17]	0.00 [0.00-0.38]	0.00 [0.00-0.96]	0.50 [0.09-2.83]
Cottonwood seedlings	0.00 [0.00-0.07]	0.00 [0.00-0.20]	0.00 [0.00-0.35]	0.85 [0.47-1.52]	1.10 [0.61-1.97]	0.00 [0.00-0.38]	0.00 [0.00-0.96]	0.00 [0.00-1.92]
Shrubs	0.00 [0.00-0.07]	0.00 [0.00-0.20]	0.00 [0.00-0.35]	0.00 [0.00-0.30]	0.00 [0.00-0.38]	0.20 [0.05-0.73]	3.25 [1.90-5.56]	2.50 [1.07-5.85]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

* A sub-group of forbs: Glycyrrhiza, Apocynum, and Asclepias.

Table 15.

Plant Species List: Laddie Park (Transects 15, 16, 17, 18)

Horsetails	Equisetum arvense L.
	Equisteum hyemale L.
Sedges & Rushes	cf. Carex aquatilis Wahlenb.
	Eleocharis sp.
	Juncus sp.
Grasses	Agropyron desertorum (Fisch.) Schult.
	Agropyron smithii Rydb.
	Agropyron trachycaulum (Link) Malte
	Agrostis alba L.
	Distichlis stricta (Torr.) Rydb.
	Oryzopsis hymenoides (R. & S.) Ricker
	Spartina pectinata Link
	Sporobolus cryptandrus (Torr.) A. Gray
	Stipa comata Trin. & Rupr. var. comata
Forbs	Apocynum cannabinum var. glaberrimum A. DC.
	cf. Chenopodium glaucum L.
	Chrysopsis villosa (Pursh) Nutt.
	Euphorbia glyptosperma Engelm.
	Franseria discolor Nutt.
	Glycyrrhiza lepidota Pursh
	Gnaphalium palustre Nutt.
	Grindelia squarrosa (Pursh) Dunal var. squarrosa
	Iva axillaris Pursh
	Lepidium medium var. pubescens (Greene) Robins.
	Medicago lupilina L.
	Potentilla anserina L. var. anserina
	Rumex fueginus Phil.
	Salsola kali L.
	Selloa glutinosa Spreng.
Woody Perennials	Artemisia ludoviciana Nutt.
	Chrysothamnus nauseosus complex
	Chrysothamnus viscidiflorus subsp. linifolius (Greene) H. & C.
	Populus sp.
	Salix exigua Nutt.
	Tamarix pentandra Pall.

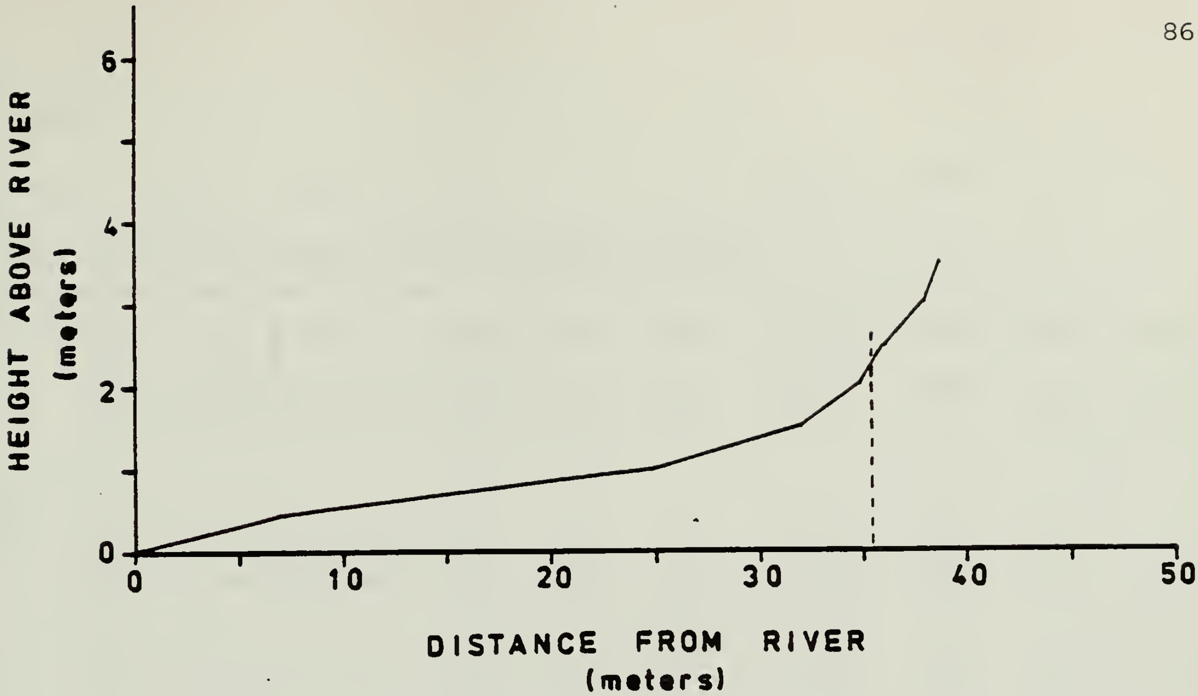


Fig. 24. Representative relief profile for Box Elder sampling location. Dashed line represents the floodline.

Table 16. Summary of substrates and vegetation coverage and density for Box Elder (Yampa) sampling location.

Elevational zone	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Substrate: mean percent [95% confidence intervals]											
Fines	84.62	7.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[77.43-89.81]	[4.74-12.02]	[0.00-2.50]	[0.00-3.37]	[0.00-6.02]	[0.00-7.13]	[0.00-8.76]	[0.00-27.75]	[0.00-27.75]	[0.00-16.11]	[0.00-27.75]
Sand	14.62	89.05	91.33	53.64	93.33	74.00	72.50	100.00	100.00	95.00	100.00
	[9.56-21.70]	[84.10-92.59]	[85.74-94.86]	[44.35-62.67]	[84.08-97.38]	[60.45-84.13]	[57.17-83.89]	[72.25-100.00]	[72.25-100.00]	[76.39-99.11]	[72.25-100.00]
Rock	0.00	2.86	8.67	46.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-2.87]	[1.32-6.09]	[5.14-14.26]	[37.33-55.65]	[0.00-6.02]	[0.00-7.13]	[0.00-8.76]	[0.00-27.75]	[0.00-27.75]	[0.00-16.11]	[0.00-27.75]
Litter	0.77	0.48	0.00	0.00	6.67	26.00	27.50	0.00	0.00	5.00	0.00
	[0.14-4.23]	[0.08-2.65]	[0.00-2.50]	[0.00-3.37]	[2.62-15.92]	[15.87-39.55]	[16.11-42.83]	[0.00-27.75]	[0.00-27.75]	[0.89-23.61]	[0.00-27.75]
Log		N	O	N	E						

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

Table 16. continued

Elevational zone	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Vegetative cover: mean percent absolute cover [95% confidence intervals]											
Total cover	3.08	4.76	16.67	15.46	35.00	48.00	30.00	0.00	10.00	10.00	10.00
	[1.20-7.64]	[2.61-8.54]	[11.55-23.44]	[9.88-23.36]	[24.17-47.64]	[34.80-61.49]	[18.08-45.43]	[0.00-27.75]	[1.79-40.41]	[2.79-30.10]	[1.79-40.41]
Horsetails			N	O	N	E					
Sedges-Rushes	0.00	0.00	10.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-2.87]	[0.00-1.80]	[6.67-16.62]	[0.00-3.37]	[0.00-6.02]	[0.00-7.13]	[0.00-8.76]	[0.00-27.75]	[0.00-27.75]	[0.00-16.11]	[0.00-27.75]
Grass	0.00	0.00	0.00	0.00	20.00	34.00	7.50	0.00	10.00	10.00	10.00
	[0.00-2.87]	[0.00-1.80]	[0.00-2.50]	[0.00-3.37]	[11.83-31.78]	[22.44-47.84]	[2.58-19.86]	[0.00-27.75]	[1.79-40.41]	[2.79-30.10]	[1.79-40.41]
Forbs (all)	2.31	4.76	5.33	12.73	13.33	14.00	17.50	0.00	0.00	0.00	0.00
	[0.79-6.56]	[2.61-8.54]	[2.73-10.17]	[7.74-20.23]	[6.92-24.16]	[6.95-26.18]	[8.75-31.95]	[0.00-27.75]	[0.00-27.75]	[0.00-16.11]	[0.00-27.75]
G-A-A *	2.31	4.76	5.33	8.18	10.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.79-6.56]	[2.61-8.54]	[2.73-10.17]	[4.36-14.82]	[4.66-20.15]	[0.00-7.13]	[0.00-8.76]	[0.00-27.75]	[0.00-27.75]	[0.00-16.11]	[0.00-27.75]
Woody perennials (all)	0.00	0.00	0.67	2.73	0.00	0.00	15.00	0.00	0.00	0.00	0.00
	[0.00-2.87]	[0.00-1.80]	[0.12-3.68]	[0.93-7.71]	[0.00-6.02]	[0.00-7.13]	[2.58-19.86]	[0.00-27.75]	[0.00-27.75]	[0.00-16.11]	[0.00-27.75]
Willow			N	O	N	E					
Tamarisk	0.00	0.00	0.67	2.73	0.00	0.00	7.50	0.00	0.00	0.00	0.00
	[0.00-2.87]	[0.00-1.80]	[0.12-3.68]	[0.93-7.71]	[0.00-6.02]	[0.00-7.13]	[2.58-19.86]	[0.00-27.75]	[0.00-27.75]	[0.00-16.11]	[0.00-27.75]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

* A sub-group of forbs: Glycyrrhiza, Apocynum, and Asclepias.

Table 16. continued

Vegetative density: mean number of plants per square meter [95% confidence intervals]

Elevational zone	I	II	III	IV	V	VI	VII	VII	IX	X	XI
Forbs (all)	0.00	9.48	8.07	8.00	14.67	6.60	19.25	0.00	0.00	0.00	0.00
	[0.00-0.30]	[8.25-10.89]	[6.74-9.64]	[6.49-9.85]	[11.91-18.07]	[4.70-9.27]	[15.40-24.06]	[0.00-3.84]	[0.00-3.84]	[0.00-1.92]	[0.00-3.84]
G-A-A *	0.00	2.62	2.20	0.00	5.50	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-0.30]	[2.01-3.41]	[1.57-3.09]	[0.00-0.35]	[3.92-7.72]	[0.00-0.77]	[0.00-0.96]	[0.00-3.84]	[0.00-3.84]	[0.00-1.92]	[0.00-3.84]
Woody perennials											
Tamarisk seedlings	0.00	0.00	15.47	3.00	5.50	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-0.30]	[0.00-0.18]	[13.60-17.59]	[2.14-4.21]	[3.92-7.72]	[0.00-0.77]	[0.00-0.96]	[0.00-3.84]	[0.00-3.84]	[0.00-1.92]	[0.00-3.84]
mature	0.08	0.00	0.73	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.01-0.44]	[0.00-0.18]	[0.41-1.31]	[0.05-0.66]	[0.00-0.64]	[0.00-0.77]	[0.00-0.96]	[0.00-3.84]	[0.00-3.84]	[0.00-1.92]	[0.00-3.84]
Cottonwood seedlings	0.00	0.00	0.73	0.00	1.83	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-0.30	[0.00-0.18]	[0.41-1.31]	[0.00-0.35]	[1.02-3.28]	[0.00-0.77]	[0.00-0.96]	[0.00-3.84]	[0.00-3.84]	[0.00-1.92]	[0.00-3.84]
mature		N	O	N	E						
Shrubs	0.00	0.00	0.00	0.09	0.00	0.40	0.00	0.00	0.00	0.00	1.00
	[0.00-0.30]	[0.00-0.18]	[0.00-0.26]	[0.02-0.51]	[0.00-0.64]	[0.11-1.46]	[0.00-0.96]	[0.00-3.84]	[0.00-3.84]	[0.00-1.92]	[0.18-5.66]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

* A sub-group of forbs: <u>Glycyrrhiza</u>, <u>Apocynum</u>, and <u>Asclepias</u>.

Table 17.

Plant Species List: Box Elder (Transects 19, 20, 21)

Horsetails	*Equisetum arvense* L. *Equisetum hyemale* L.
Sedges & Rushes	cf. *Carex aquatilis* Wahlenb. *Eleocharis* sp.
Grasses	*Agropyron smithii* Rydb. *Distichlis stricta* (Torr.) Rydb. *Elymus canadensis* L. *Sporobolus cryptandrus* (Torr.) A. Gray
Forbs	*Apocynum cannabinum* var. *glaberrimum* A. DC. cf. *Chenopodium glaucum* L. *Chrysopsis villosa* (Pursh) Nutt. *Iva axillaris* Pursh *Rumex fueginus* Phil. *Salsola kali* L.
Woody Perennials	*Artemisia ludoviciana* Nutt. *Artemisia tridentata* Nutt. *Chrysothamnus viscidiflorus* subsp. *linifolius* (Greene) H. & C. *Populus* sp. *Tamarix pentandra* Pall.

Summary: the Yampa

The transect data from the Yampa River show several general patterns which are indicative of the role played by the high spring discharges in controlling vegetation along the river corridor. Looking from the water's edge to the dry upland slopes during the summer low-discharge period, one observes not only changes in the dominance of certain species, but major changes in species composition, growth-form, density, coverage, and species richness. A dramatic change occurs in these parameters at or near the point which we have designated the floodline, indicating that flooding has a major and direct impact on vegetation.

Two principal components of flooding influence vegetation, inundation and scouring. The former is simply the result of rise in river stage as discharge increases. The latter is the effect of movement of the water and suspended particles flowing across a particular point. In the geologic sense, scouring refers to the movement of the mineral substrate from the channel bed by the action of moving water, and indeed the wholesale removal of seasonally vegetated streamside deposits has a definitive effect on vegetation patterns, and particularly opportunities for colonization or succession. In this study scouring is also used to indicate the damage or removal of plant material, either living or dead, by the same forces. Since both depth and velocity of a river increases with discharge (Leopold et al. 1964), separation of the effects of inundation and scouring is not always possible.

In reservoir systems, the principal detrimental effect of inundation on shoreline vegetation is the creation of anaerobic conditions in the rhizosphere (Whitlow and Harris, 1979; Potter and Pattison 1976). This is probably not the case for rivers where the low water temperatures and constant movement will act to maintain dissolved oxygen concentrations. Anaerobic soil conditions may occur

very locally where the water is quiet and fine sediments are deposited and saturated, but such areas are insignificant in the total river environment.

The primary effect of inundation on the floodzone vegetation of the Yampa River is in limiting the length of the growing season. Floodzone plants must be able to break dormancy, grow, and reproduce between the time they are exposed (usually sometime in June, depending upon the behavior of the river and the elevation of the plant within the floodzone) and the end of the growing season (late September or early October). These conditions will favor rapid growth over slow, perennials over annuals, and growth high in floodzone over low.

Some species were observed to circumvent this problem. As was noted above, Polygonum amphibium maximized its growing season by beginning growth as a submergent and developing as a terrestrial plant after exposed. Both willow and tamarisk were observed to have foliage on exposed stems, even when the base of the plant was still submerged (Figs. 25 and 26). The ability of tamarisk to survive inundation has been noted by Gary (1963), Cooper (1963), and Potter and Pattison (1976).

Scouring can affect plants in several ways. The shear stress exerted by moving water on stems may exceed their elastic limits, causing breakage. If the root system of the plant is poorly developed or is in loose substrate, the entire plant may be pulled out. This may be aided by the movement of the substrate by the water, particularly if the substrate is sand. Finally, the particulate matter carried by the water can abrade aboveground plant tissues. Abrasion is probably greatest at the plant base from larger particles moved along the bed, but not lifted into the current.

Most plants found in the floodzone exhibited characteristics which enabled them to resist the effects of scouring. Since seeds and seedlings would be highly susceptible to removal, it is not surprising that the floodzone plants

Fig. 25. Willows on a submerged gravel island are able to continue growth even when most of the plant is inundated.

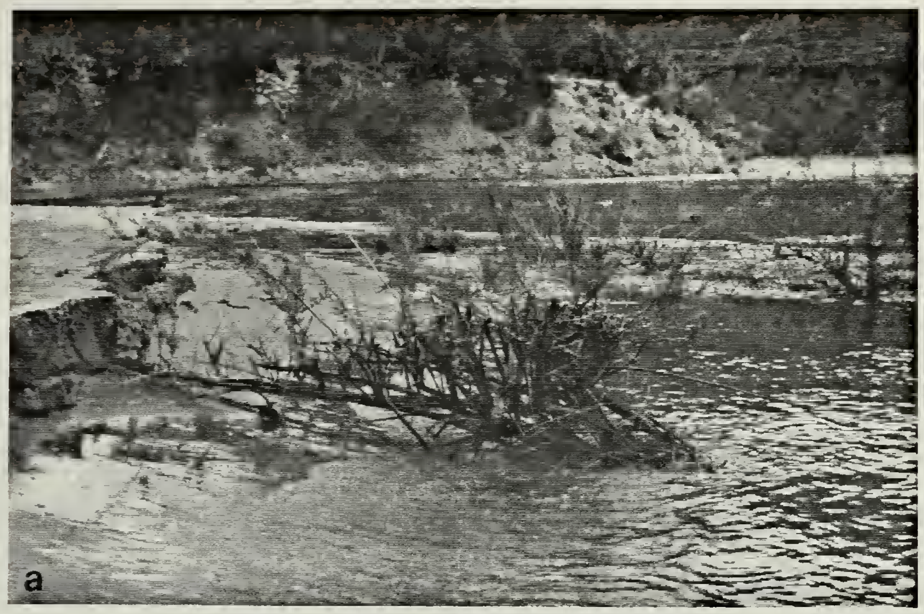


Fig. 26a and b. The ability of tamarisks to survive inundation and scouring is revealed in this pair of photographs of the same plant, in June (Photo A) and September (Photo B). Note that the plant is flowering in B.

were almost exclusively perennials capable of vegetative reproduction. Most of these exhibited annual aboveground parts which could be scoured away each year and perennial below-ground tissues, either roots or rhizomes. The dominant species of this type were: *Equisetum hyemale*, *E. laevigatum*, *Carex aquatilis*, *Eleocharis* sp., *Juncus* sp. (rush), *Glycyrrhiza lepidota*, *Apocynum cannabinum*, *Asclepias* sp., *Polygonum amphibium*, *Iva axillaris*, and *Franseria discolor*. Grasses also have these characteristics, but were not commonly found far below the floodline.

Willow and tamarisk stems are capable of surviving the direct effects of scouring. The frequent occurrence of willow suggests that willow is more resistant. Young stems of these species are flexible, allowing them to resist breakage. The absence of stems much exceeding 1 cm in diameter in the floodzone indicates an age limit to this resistance. Both species are capable of sprouting from roots (Fig. 27).

Young cottonwoods were limited to the upper part of the floodzone and the quieter water of side channels, indicating less resistance to scouring than either willow or tamarisk. Root sprouting has been reported for several species of cottonwood (Irvine and West 1979), but we found no evidence of sprouting along the Yampa.

Tamarisk stem ages from the sampling site at Big Joe Rapids reveal that recruitment of stems in tamarisk stands, whether by seed or sprouting, occurs in pulses rather then at a constant rate (Fig. 28). The stems from the highest terrace were the oldest, dating from 1969 and 1970. Only three of the 17 stems cut were dated between 1970 and 1978. Over half (53%) were from the year 1978. These included stems from both of the lower terraces.

When these data are compared to the maximum average monthly discharge for the river, no particular pattern is apparent, but we note that the year prior to

Fig. 27. Root sprouts from an exposed willow root.

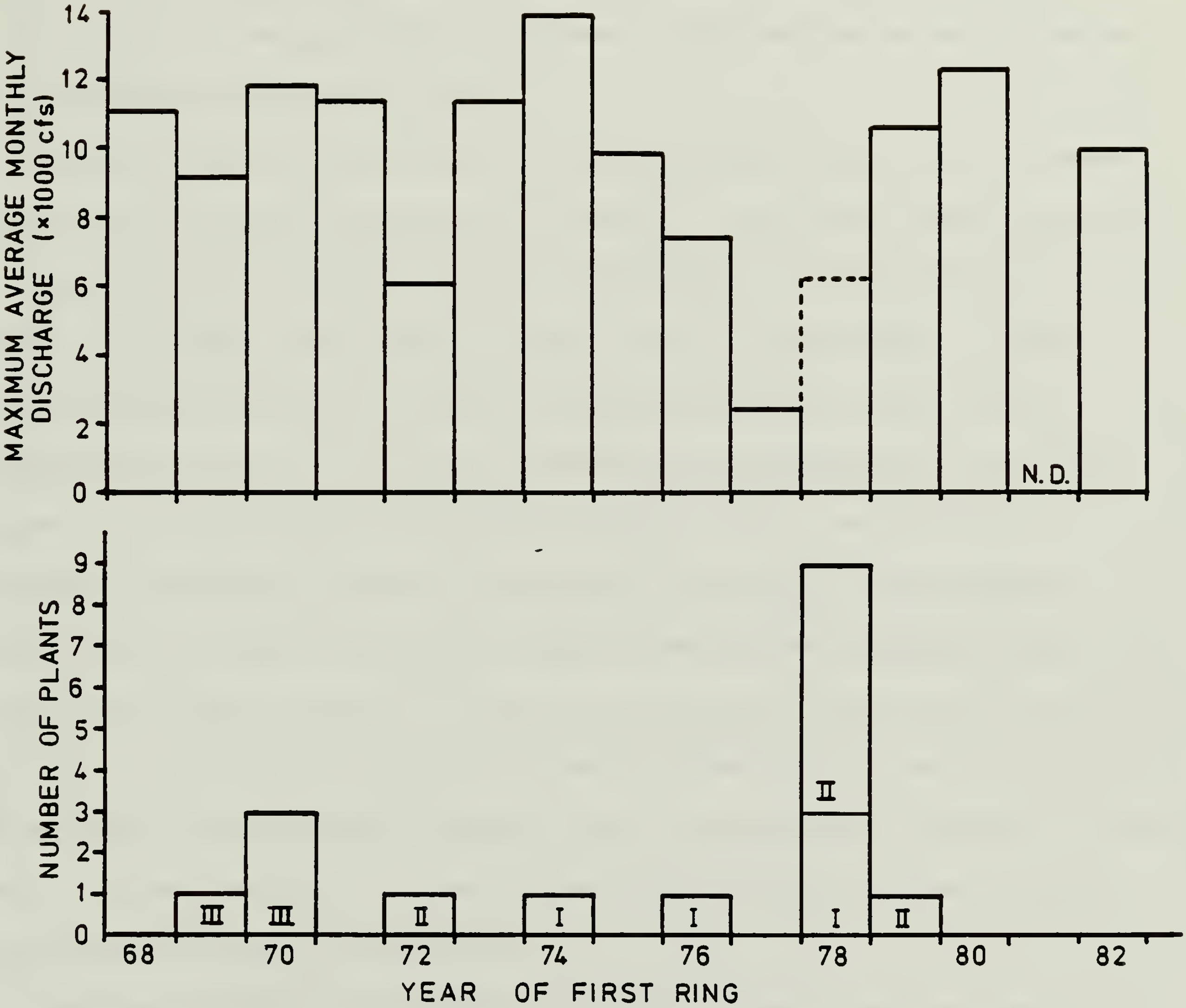


Fig. 28. Tamarisk stem ages from Big Joe Rapids with the average monthly discharge of the Yampa River. Numerals indicate the flood terrace from which the plants were cut (I = lowest).

the 1978 pulse in stem recruitment was an unusually low water year. It is possible that this low water year either stimulated root sprouting the following year, or that seedlings produced in 1976 were able to escape scouring the following year, allowing greater development of the root system and production of large, flood-resistant stems in 1978.

Years of unusually high or low flow are apparently critical to the sexual reproduction of willow, cottonwood, and tamarisk. Cottonwood flowers once each year and the release of seeds is usually synchronous with the spring flood (Horton et al. 1960). The period of seed viability is very short. During normal flood years, such as the year of this study, most of the seeds are deposited and germinate in the moist substrate of the floodzone, only to be scoured away the following year (Irvine and West 1979). Low discharge or protection by rocks may prevent the scouring of seedlings or young plants. If the peak flow is higher than normal, seedlings may become established above the floodline and escape scouring if floods in the following year are not excessively high, (Fig. 28A.) This is probably the source of most of the mature cottonwoods such as found at Anderson Hole, Haystack Rock, and scattered locations along the river. Our observations of willow seem to indicate that it follows a similar phenological strategy and distribution.

Tamarisk is capable of flowering and producing seed throughout the growing season and is therefore less dependent upon the late spring flood period for establishment (Warren and Turner 1975). As indicated by the high seedling densities recorded along the Yampa, the reproductive potential of this species far exceeds that of willow or cottonwood (see also Tomanek and Ziegler 1961).

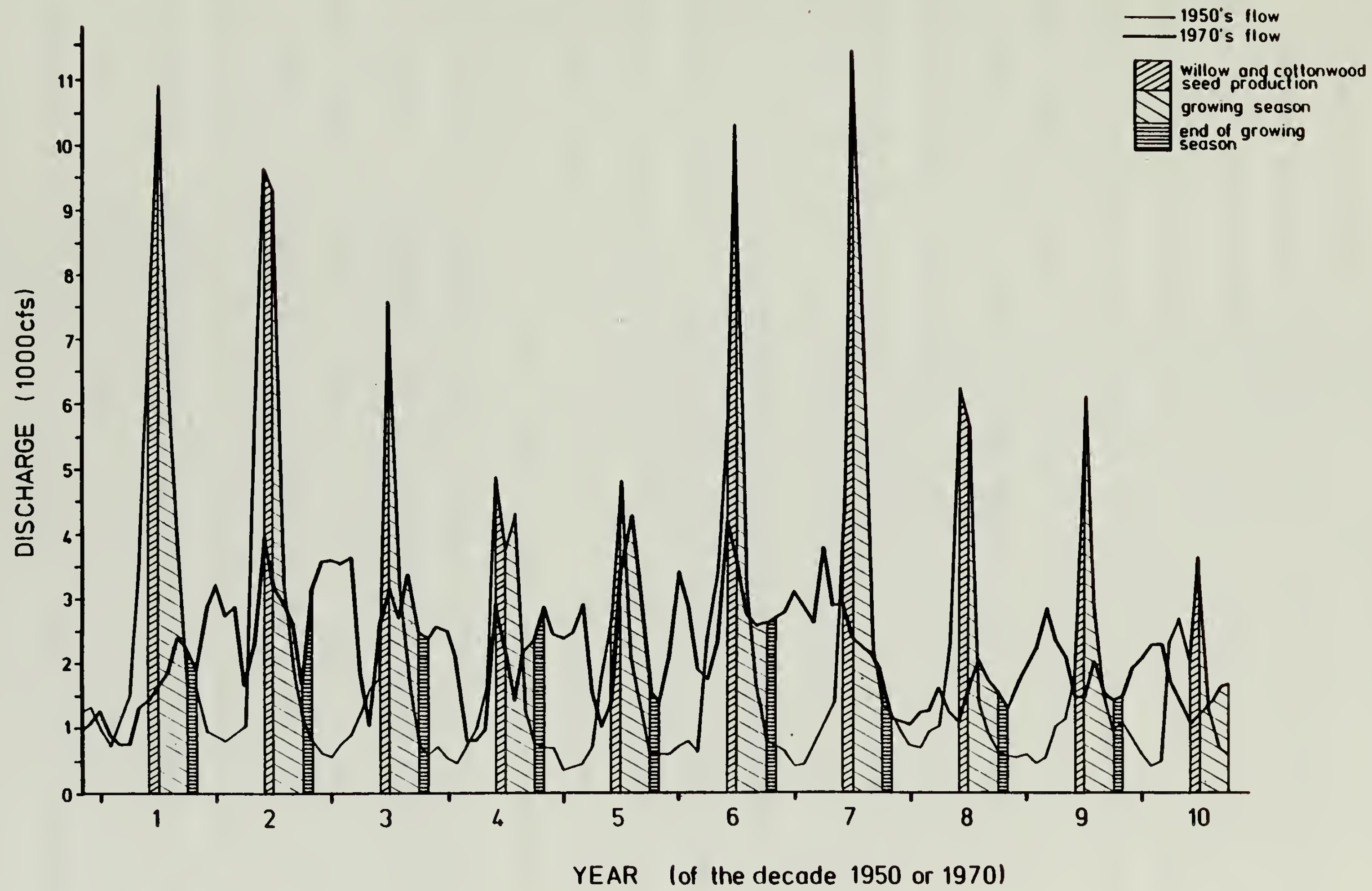


Fig. 28A. Comparison of unregulated and regulated flow of Green River in 1950s and 1970s (before and after the dam) and the relationship of fluctuating water levels to the phenology of willow and cottonwood.

The disparity between the density of seedlings and of older plants is indicative of the low survivorship of these plants through the first year when normal spring flooding occurs.

Tamarisk seedlings were very dense in some locations, particularly on sandbars in the lower half of the river (Fig. 29), and sparse or absent in others. They often appeared in distinct bands across sand deposits, indicating successive dispersal events correlated either with reproductive periodicity of parental trees or with the rise and fall of river levels.

Analysis of the substrate texture from these locations (Fig. 30) revealed that in all cases when seedlings occurred there was at least a narrow band of sediment containing a minimum of 20% fine sand, silt, and clay within the root zone (Fig. 31). Beach areas bare of seedlings at the same locations did not always contain such a layer of fine sediments. There appears, then, to be a relationship between substrate texture and tamarisk seedling establishment, but it can not be determined from this small sample of observations whether the seedlings require fine-textured substrate (which have better moisture-holding capacity than the well sorted medium- or coarse-textured sands) or whether the seeds are simply deposited under the same conditions which favor deposition of fine sediments. Elsewhere greater survivorship of seedlings has been tied to the moisture-holding capacity of fine sediments (Simons 1979).

Historical photographs of the Yampa River (Figs. 32 to 37) reveal the dynamic nature of the river and the pattern of repeated change occurring within the floodzone. Bank cutting and stabilization by vegetation operate as continual, alternating processes. Stands of floodzone species repeatedly become established and are removed. The dominant aspect of the floodzone is, however, that its general nature has not changed significantly during the period of photographic record. The single most striking change in vegetation is the establishment of the exotic tamarisk, particularly at Mather's Hole.

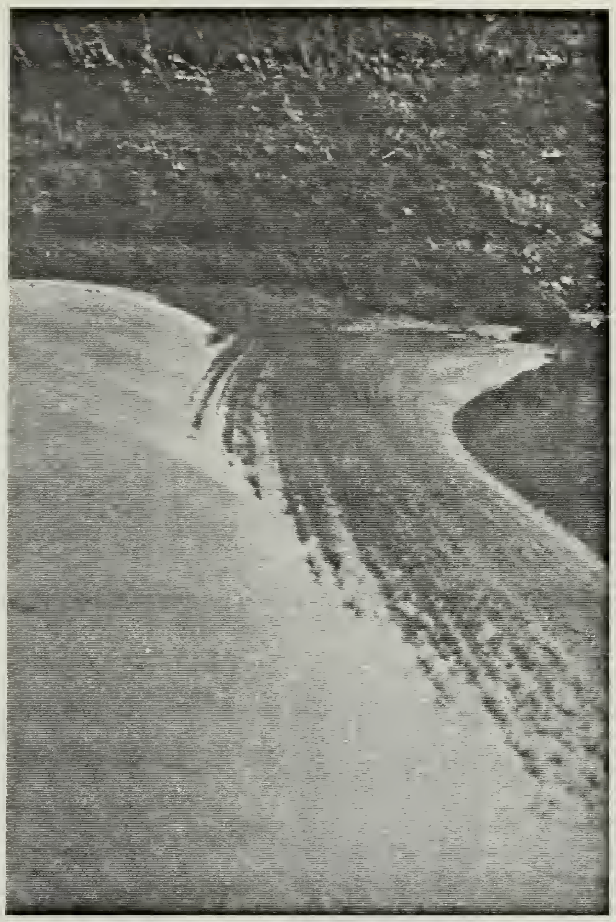


Fig. 29. An extremely dense stand of tamarisk seedlings is seen here on a sand bar near Mile 7 on the Yampa River. Note the arrangement of seedlings in horizontal bands in the foreground.

Fig. 30. Excavation of the sand beneath the rows of tamarisk seedlings reveal the presence of bands of finer (dark) sediments near the surface.

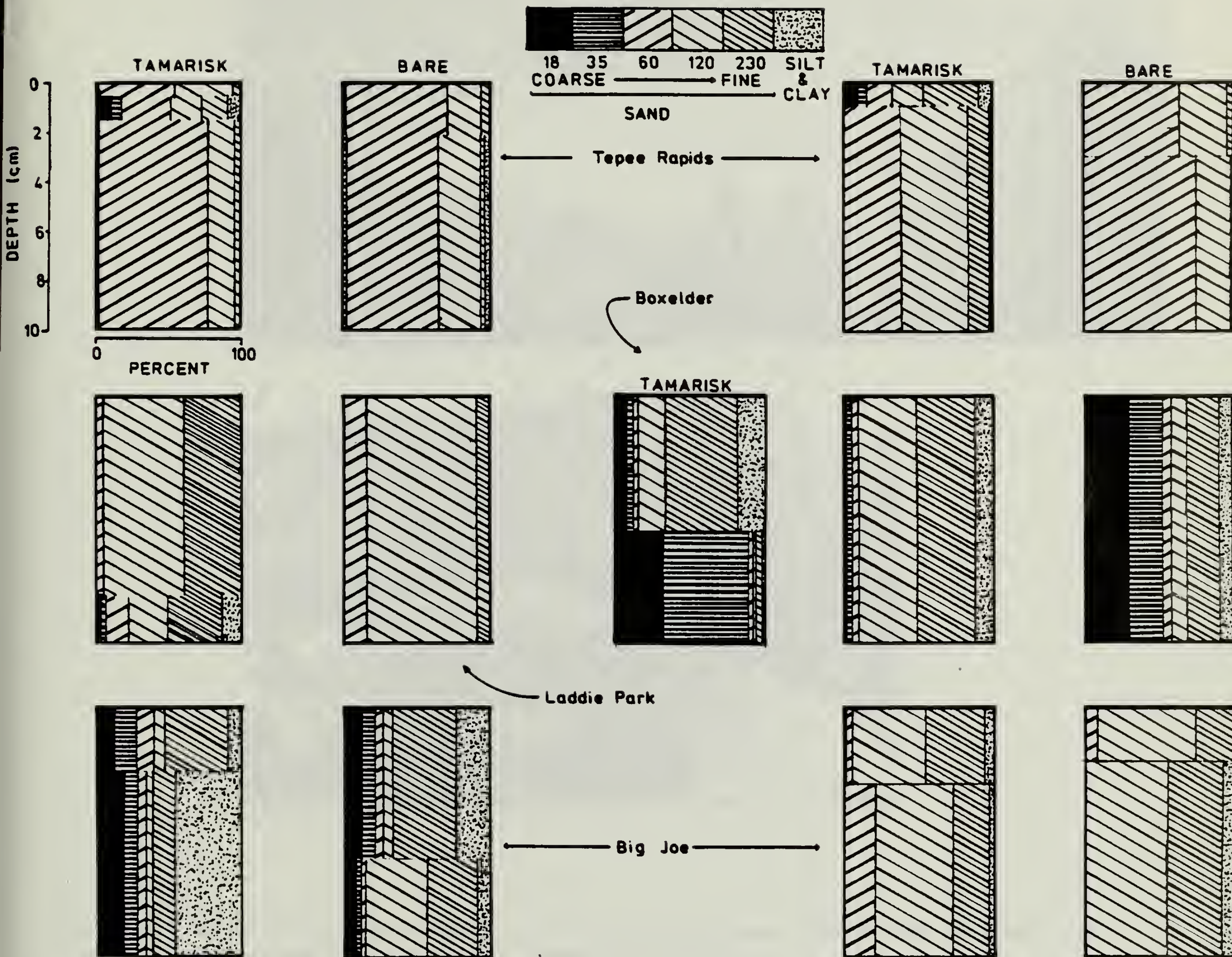


Fig. 31. Results of the soil analysis from four locations. Samples with seedlings are in a column under the "TAMARISK" heading and without seedlings are under "BARE".

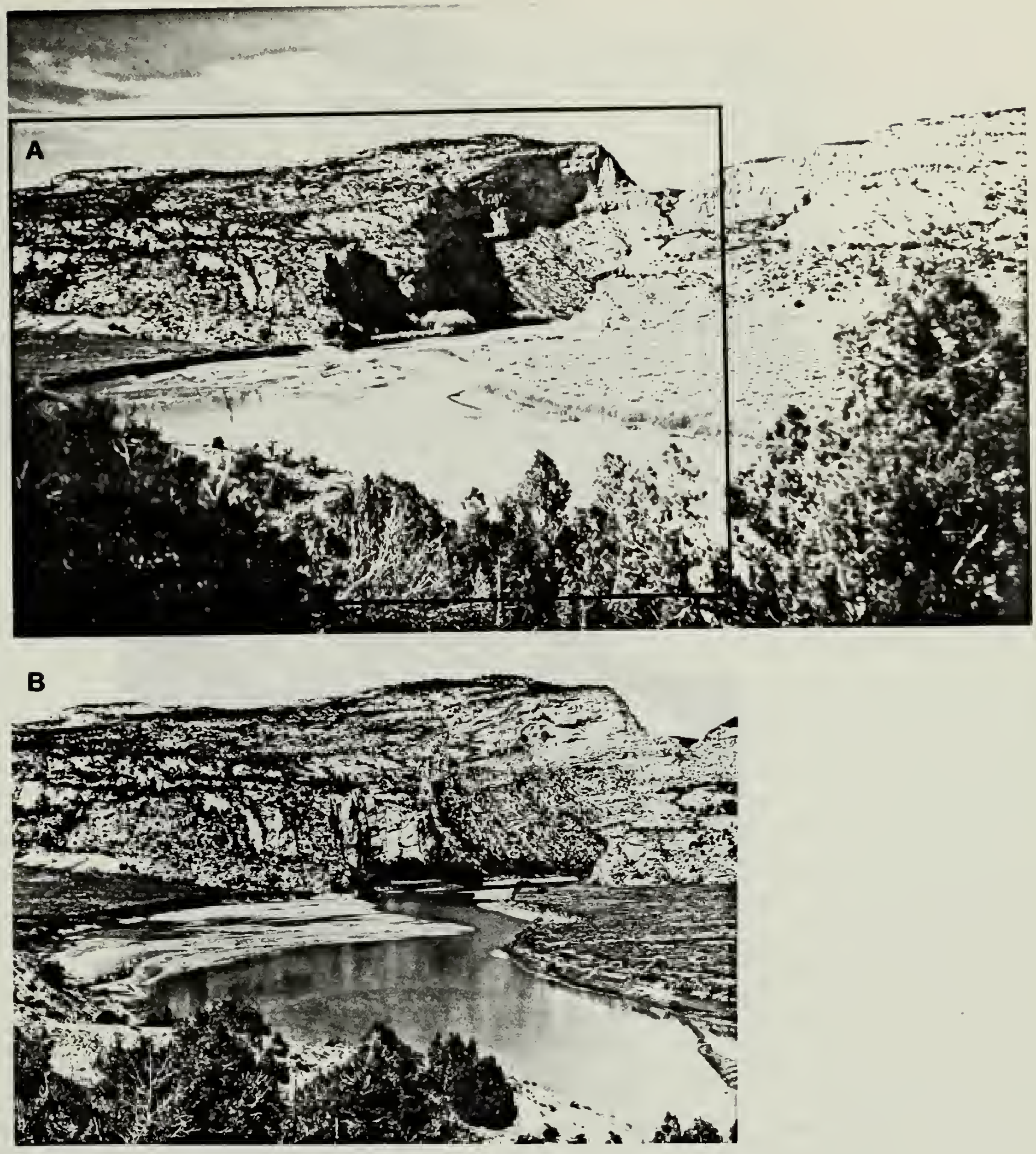


Fig. 32. Yampa River, Mile 45.5. Looking downstream toward the entrance to the Yampa River Canyon, just below Deer Lodge Park.
Photo A, 12/7/45, unknown photographer, DNM N3015 #120; Photo B, 9/24/82, Fischer.
The most significant changes in the past 37 years are the erosion of the right bank and the enlargement of the sand deposits on the left. This sandy flat is the mouth of Disappointment Draw, and the dark areas in Photo B are red sediments washed out from the draw in a recent rain storm. Willows appear to line the right bank in Photo A, but these have since disappeared. The overall aspect of the river in this location has not changed significantly.

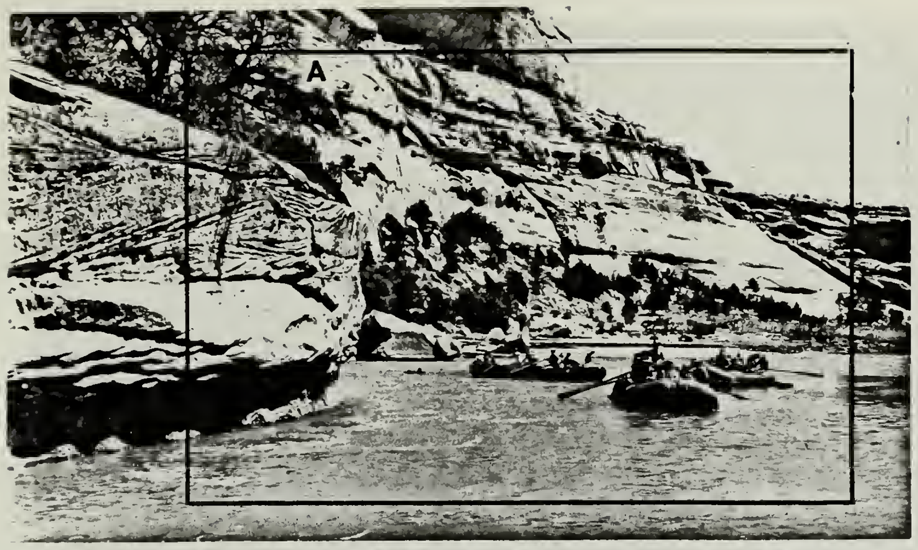


Fig. 33. Yampa River, Mile 19.4. Looking upstream toward the lower end of Harding Hole.
Photo A, 6/28/56, unknown photographer, DNM L3431 #91; Photo B, 9/26/82, Fischer. In these photos, note that the sand beach behind the boats in Photo A has been significantly enlarged in the intervening time before Photo B. The bank has been cut dramatically, removing the riparian shrubs seen in Photo A. A small clump of tamarisk can be seen on the sand at the base of the cut bank in Photo B.

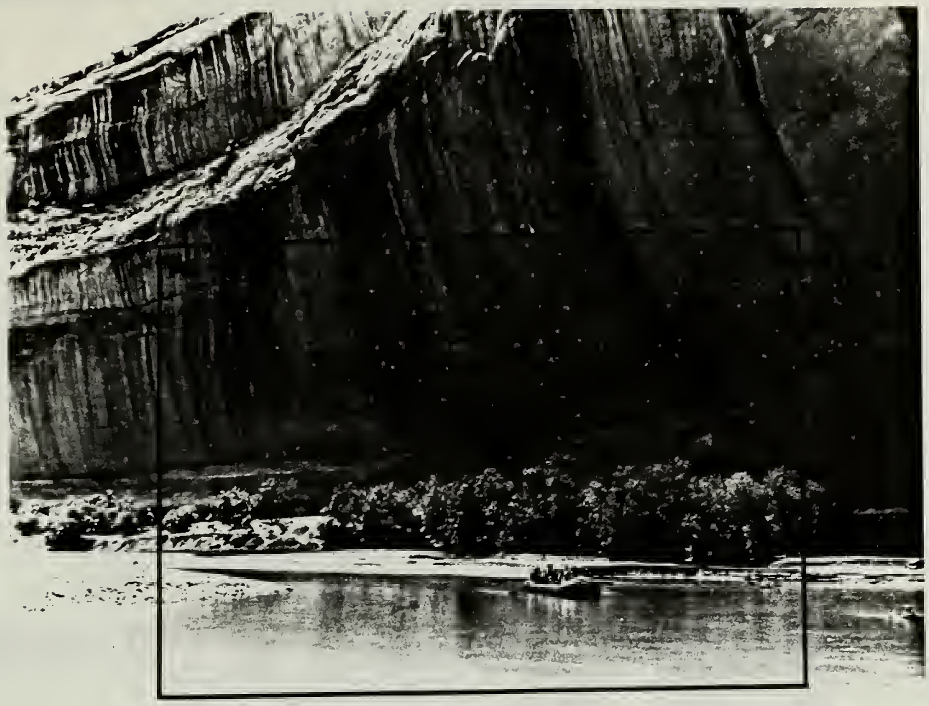


Fig. 34. Yampa River, Mile 17.6. Looking upstream at Mather's Hole. Photo A, 6/28/56, Unknown photographer, DNM L343; Photo B, 9/27/82, Fischer. In Photo B, the wispy looking plants which appear on the terrace in front of the boxelders are tamarisk. These plants have become established in the past 26 years. The fine plant material seen covering the sand below them is mostly tamarisk seedlings. The boxelders have grown considerably since 1956, but the lower portions of the floodzone are still almost devoid of plants. Evidence of cutting on the sand deposits is seen in both photographs.

A B C

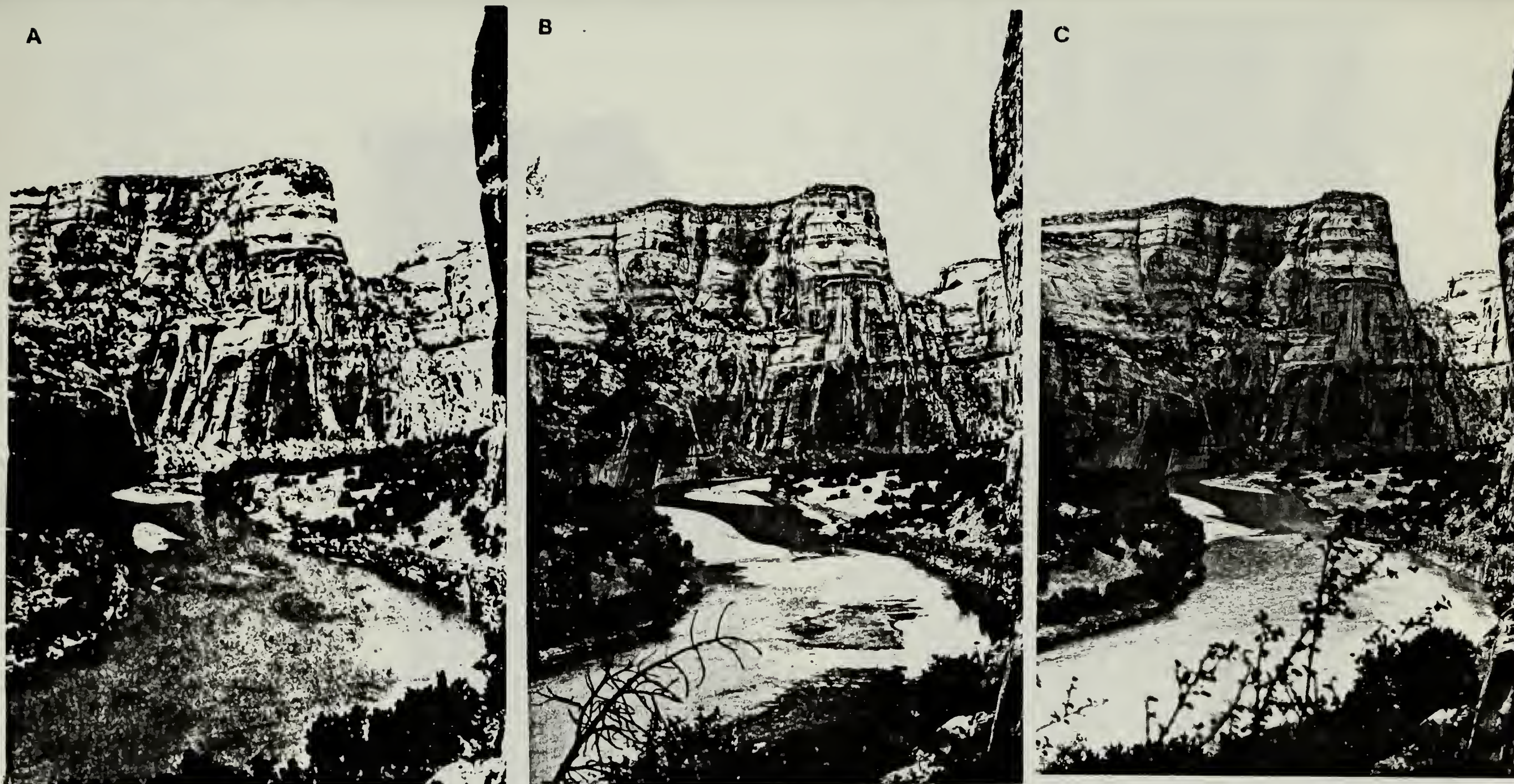
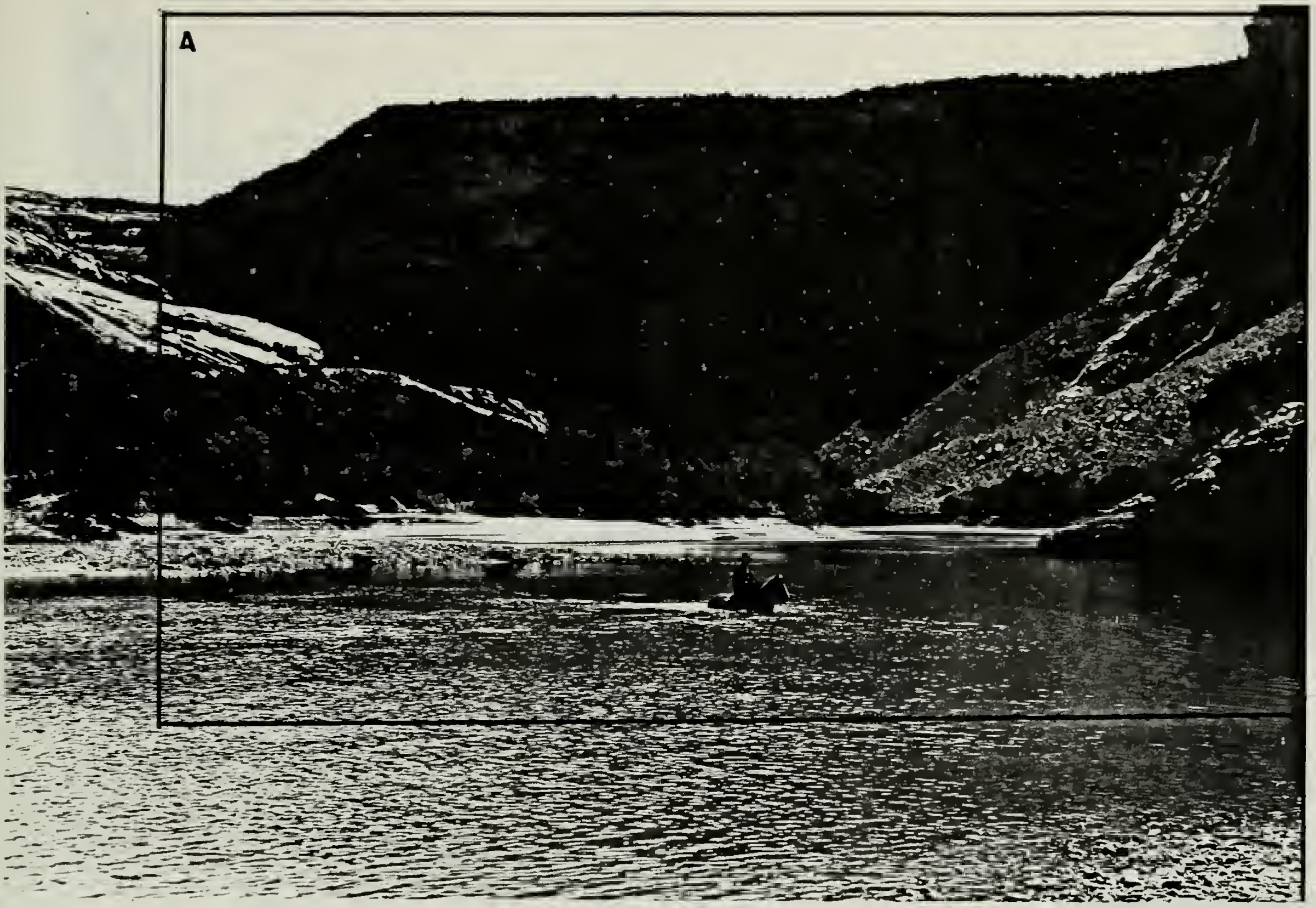


Fig. 35. Yampa River, Mile 9.3. Looking downstream.
Photo A, July 1871, Beaman & Hillers, U.S.G.S.; Photo B, July 1969, Shoemaker & Stephens, U.S.G.S.; Photo C, August 1982, Fischer.
The most striking aspect of this photo triplet is how little the river has changed in this area over the past 13 years, and even over the past 111 years. The vegetation on the point bar in Photo A appears to have been scoured away, perhaps during some particularly high flow; at present it seems to be increasing. A gravel bar appears in the foreground of Photo B; this feature is barely under the river surface in Photo C.

A



B

Fig. 36. Yampa River, Mile 1.5. Looking upstream.
Photo A, 8/8/35, unknown photographer, DNM #2439; Photo B, 8/8/82, Fischer. The gravel visible in Photo A is covered with water in Photo B. <u>Carex aquatilis</u> has become established on the gravel bar on the left. Sandy banks appear white in Photo A, but gray in Photo B due to the presence of tamarisk seedlings.

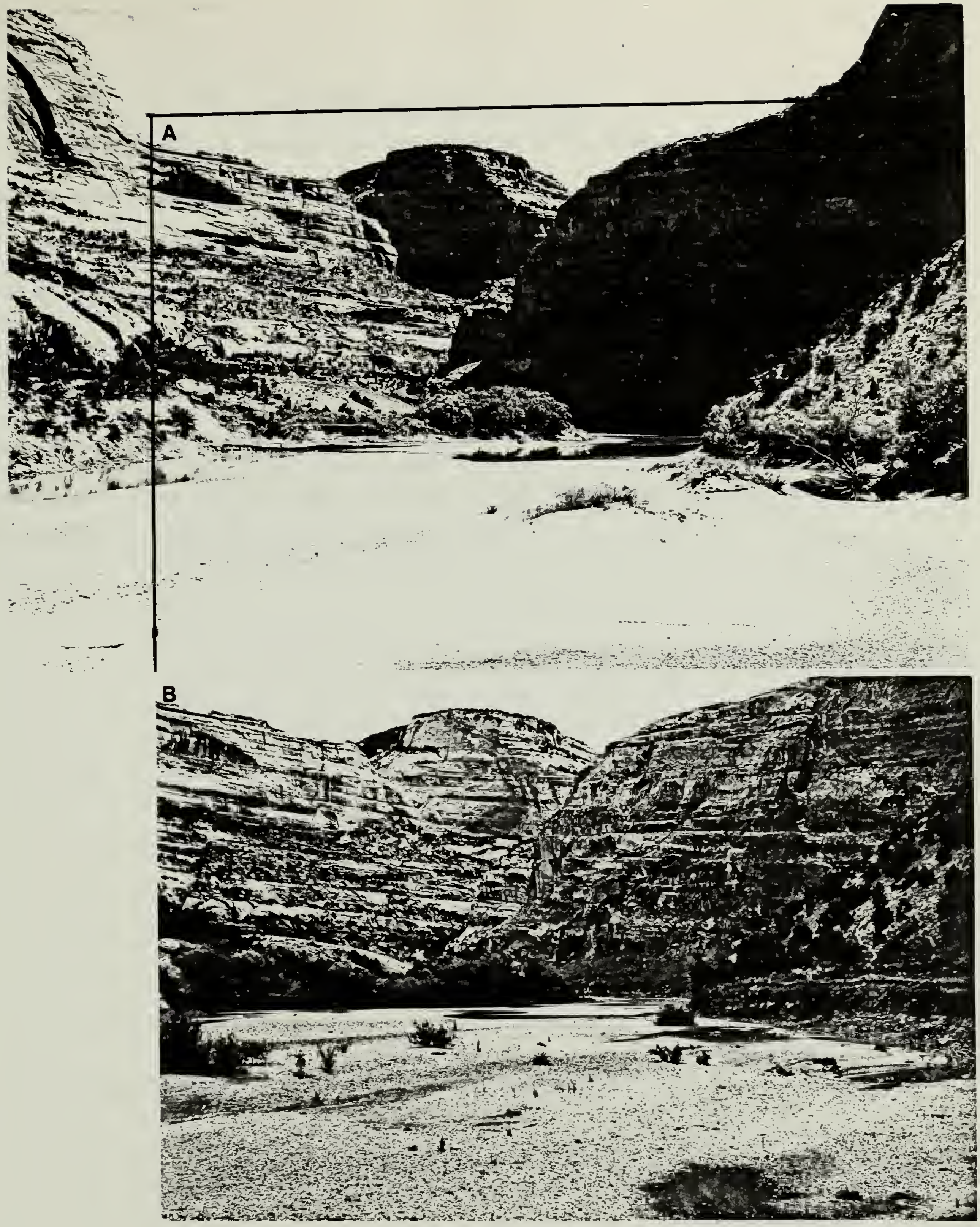


Fig. 37. Yampa River, Mile 0.5. Looking upstream.
Photo A, 8/8/35, unknown photographer, DNM N3015 #2436; Photo B, 9/29/82, Fischer. In both photographs, the large gravel flats are kept clear of most vegetation by yearly scouring. The plants which survive this scouring are woody perennials. Plants (possibly willows) seen accumulating sand around their bases in the foreground of Photo A have disappeared during the past 47 years. A few tamarisk are now established in this area. Bank erosion has shifted from the right bank to the left bank.

The Green River above the Yampa

The results of the vegetation and substrate analyses from the four sites on the Green River above the confluence with the Yampa are shown in the tabular data given for each site. The old (pre-dam) floodline was still recognizable on most transects, generally occurring within Zones IV or V. Evidence of recent inundation was not found above Zone I.

The surficial substrate at all four sites was dominated by litter above Zone I (Fig. 38). By contrast, litter accumulation in the floodzone was minimal on the Yampa due to yearly scouring. Heavy litter accumulations may influence the reproductive success of plants in these zones.

Fig. 38. High litter accumulation, as seen here at Kolb Campground during April, was typical of the old floodzone area of the Green River.

Kolb

The data from the three transects at Kolb Campground were combined in Table 18. The elevation of Transect 22, which was upstream from the gravel island, did not exceed that of the outer slope of the island (Fig. 39), and was combined with the outer slope of Transects 23 and 24.

Total plant coverage was extremely high in the lower zones of this site, particularly on the bank slope. Grasses were the primary component of coverage in Zone I. Sedges and rushes were also important in this zone (see Table 19). Forb cover was highest on the top of the gravel island. This was due to a dense stand of *Chrysopsis villosa*, a species which only occurred above the floodline on the Yampa, covering the top of the island (Fig. 40). Forb density and diversity were also high in the old channel separating the former island from the bank.

Tamarisk was sparsely scattered over the top of the island. These plants were small and had many dead stems. A few willows were also found on the island. No seedlings of these species were found, although boxelder seedlings were found in the old channel.

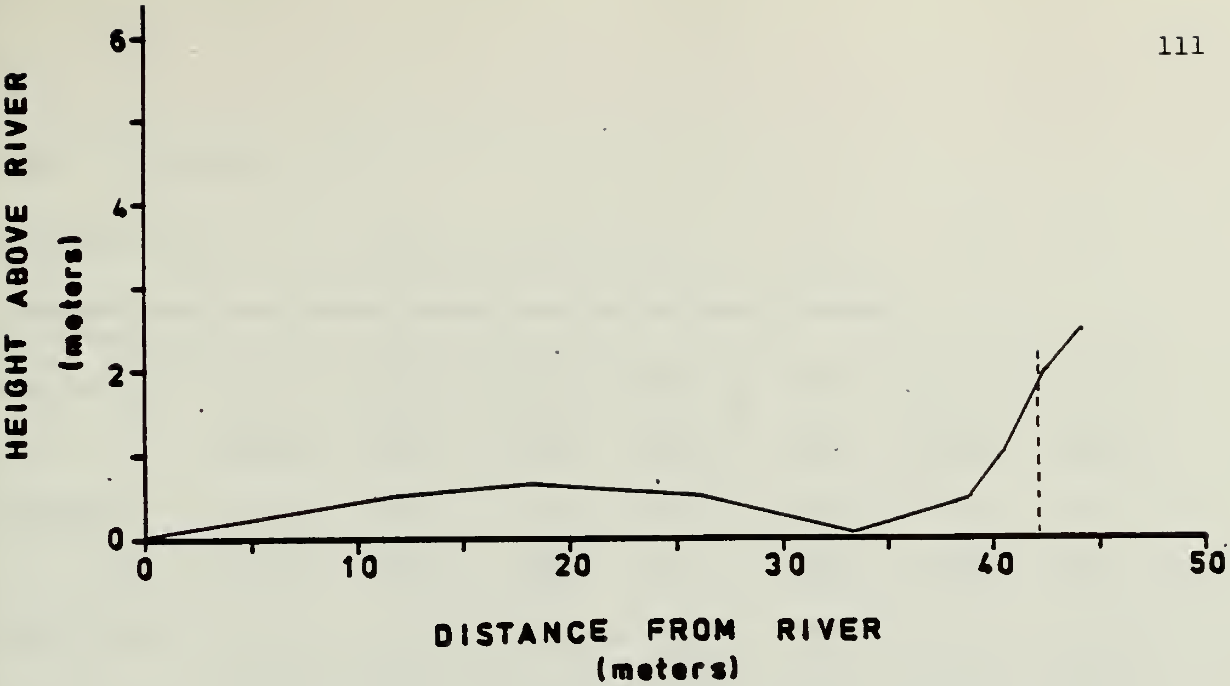


Fig. 39. Representative relief profile for Kolb sampling location. Dashed line represents the floodline.

Table 18 . Summary of substrates and vegetation coverage and density for Kolb (upper Green) sampling location.

Elevational zone	I	II	I	II	III	IV	V
Substrate: mean percent [95% confidence intervals]							
Fines	4.84	4.87	0.00	0.00	0.00	0.00	0.00
	[2.95-7.83]	[3.14-7.48]	[0.00-1.64]	[0.00-7.13]	[0.00-27.75]	[0.00-27.75]	[0.00-16.11]
Sand	17.74	5.38	0.00	0.00	0.00	30.00	0.00
	[13.89-22.38]	[3.55-8.09]	[0.00-1.64]	[0.00-7.13]	[0.00-27.75]	[10.78-60.32]	[0.00-16.11]
Rock	2.58	11.03	2.61	36.00	80.00	20.00	25.00
	[1.31-5.01]	[8.29-14.52]	[1.20-5.57]	[24.14-49.86]	[49.02-94.33]	[5.67-50.98]	[11.19-46.87]
Litter	74.84	78.46	97.39	64.00	10.00	40.00	75.00
	[69.72-79.34]	[74.12-82.25]	[94.43-98.80]	[50.14-75.86]	[1.79-40.41]	[16.82-68.73]	[53.13-88.81]
Log	0.00	0.26	0.00	0.00	10.00	10.00	0.00
	[0.00-1.22]	[0.04-1.44]	[0.00-1.64]	[0.00-7.13]	[1.79-40.41]	[1.79-40.41]	[0.00-16.11]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

Table 18 . continued

Vegetative cover: mean percent absolute cover [95% confidence intervals]

Elevational zone	I	II	I	II	III	IV	V
Total cover	64.19 [58.71-69.33]	47.69 [42.78-52.65]	81.30 [75.77-85.81]	88.00 [76.20-94.38]	40.00 [16.82-68.73]	30.00 [10.78-60.32]	30.00 [14.55-51.89]
Horsetails	5.81 [3.70-8.99]	2.31 [1.22-4.33]	1.74 [0.68-4.38]	0.00 [0.00-7.13]	10.00 [1.79-40.41]	0.00 [0.00-27.75]	0.00 [0.00-16.11]
Sedges & Rushes	11.61 [8.51-15.66]	0.00 [0.00-0.98]	17.39 [13.04-22.81]	6.00 [3.06-16.21]	0.00 [0.00-27.75]	0.00 [0.00-27.75]	0.00 [0.00-16.11]
Grass	26.13 [21.53-31.29]	4.87 [3.14-7.48]	46.52 [40.19-52.97]	50.00 [36.66-63.35]	10.00 [1.79-40.41]	10.00 [1.79-40.41]	0.00 [0.00-16.11]
Forbs	20.00 [15.93-24.81]	41.54 [36.75-46.49]	17.83 [13.42-23.29]	24.00 [14.30-37.41]	20.00 [5.67-50.98]	10.00 [1.79-40.41]	5.00 [0.89-23.61]
Woody perennials							
Tamarisk	6.13 [3.96-9.37]	0.77 [0.26-2.24]	1.30 [0.44-3.76]	0.00 [0.00-7.13]	0.00 [0.00-27.75]	0.00 [0.00-27.75]	0.00 [0.00-16.11]

Vegetative density: mean number of plants per square meter [95% confidence intervals]

Elevational zone	I	II	I	II	III	IV	V
Forbs (all)	29.35 [27.51-31.32]	37.28 [35.41-39.25]	108.09 [103.92-112.42]	33.20 [28.52-38.65]	55.00 [42.26-71.58]	33.00 [23.50-46.34]	27.50 [21.13-35.79]
G-A-A *	0.35 [0.20-0.64]	0.28 [0.16-0.51]	0.96 [0.63-1.45]	0.00 [0.00-0.77]	0.00 [0.00-3.84]	0.00 [0.00-3.84]	0.00 [0.00-1.92]
Woody perennials Willow	0.16 [0.07-0.38]	0.03 [0.00-0.15]	0.00 [0.00-0.17]	0.00 [0.00-0.77]	0.00 [0.00-3.84]	0.00 [0.00-3.84]	0.00 [0.00-1.92]
Tamarisk	0.19 [0.09-0.42]	0.10 [0.04-0.26]	0.13 [0.04-0.38]	0.00 [0.00-0.77]	0.00 [0.00-3.84]	0.00 [0.00-3.84]	0.00 [0.00-1.92]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

* A sub-group of forbs: Glycyrrhiza, Apocynum, and Asclepias.

Table 19.

Plant Species List: Kolb (Transects 22, 23, 24)

Horsetails	Equisetum arvense L.
	Equisetum laevigatum A. Br.
Sedges & Rushes	Carex lanuginosa Michx.
	Juncus balticus Engelm.
	Juncus longistylis Torr.
	Scirpus americanus Pers.
Grasses	Agropyron pseudorepens Scribn.
	Agropyron repens (L). Beauv.
	Agrostis alba L.
	cf. Bromus sp.
	Calamagrostis scopulorum Jones
	Distichlis stricta (Torr.) Rydb.
	Elymus canadensis L.
	Muhlenbergia asperifolia (Nees May) Parodi
	Spartina gracilis Trin.
Forbs	Apocynum cannabinum var. glaberrimum A. DC.
	Aster hesperinus Gray var. hesperinus
	Chrysopsis villosa (Pursh) Nutt.
	Cirsium sp.
	unk. Compositae
	Gnaphalium palustre Nutt.
	Iva axillaris Pursh
	Medicago lupilina L.
	Mentha arvensis L.
	Polygonum sp.
	Potentilla anserina L. var. anserina
	Ranunculus cymbalaria Pursh var. saximontanus Fern.
	cf. Rumex sp.
	Selloa glutinosa Spreng.
	cf. Veronica sp.
Woody Perennials	Acer negundo L.
	Artemisia ludoviciana Nutt.
	Juniperus utahensis Engelm. (Lemmon)
	Tamarix pentandra Pall.

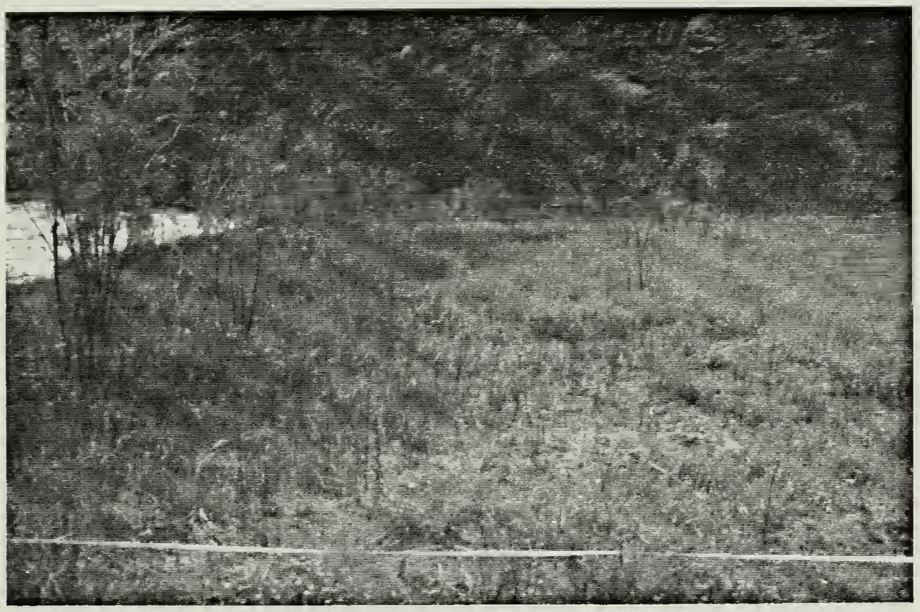


Fig. 40. The sampling site at Kolb Campground as it appeared in August shows a distinct line separating the xerophytic vegetation on the top of the island (right) from the mesophytic vegetation closer to the floodline (left). Note the decadence of the tamarisk plants scattered across this gravel island.

Harp Falls

Harp Falls (Fig. 41) showed a similar pattern of vegetation cover to Kolb (Tables 20 and 21). Coverage was highest in Zone II. Zones II, III, and IV (Fig. 42) were dominated by a dense stand of *Equisetum laevigatum* (Fig. 43), which was probably a relict from the pre-dam floodzone vegetation. Near the water's edge, grasses dominated the vegetation, particularly *Agrostis alba*, *Deschampsia caespitosa*, *Hordeum* sp., and *Agropyron repens*. Scattered small tamarisk were also found in the lower zones of this site.

Fig. 41. Harp Falls was sampled when the discharge of the Green was relatively low, exposing this flat area which held many wetland species.

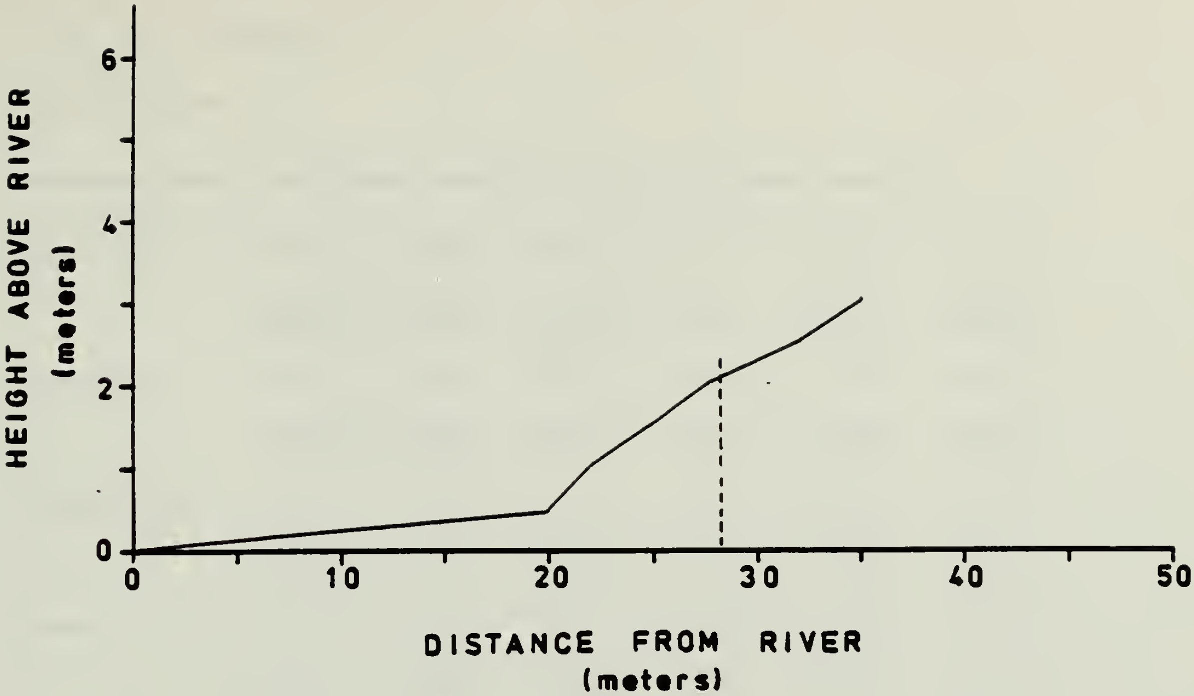


Fig. 42. Representative relief profile for Harp Falls sampling location. Dashed line represents the floodline.

Table 20. Summary of substrates and vegetation coverage and density for Harp Falls (upper Green) sampling location.

Elevational zone	I	II	III	IV	V	VI
Substrate: mean percent [95% confidence intervals]						
Fines	N O N E					
Sand	71.25	32.00	16.00	30.00	48.75	46.67
	[66.63-75.47]	[20.76-45.81]	[8.34-28.51]	[21.07-40.77]	[38.11-59.50]	[30.23-63.86]
Rock	15.75	0.00	0.00	0.00	0.00	0.00
	[12.51-19.64]	[0.00-7.13]	[0.00-7.13]	[0.00-4.58]	[0.00-4.58]	[0.00-11.35]
Litter	13.00	68.00	82.00	41.25	41.25	53.33
	[10.05-16.65]	[54.19-79.24]	[69.21-90.23]	[31.11-52.19]	[31.11-52.19]	[36.14-69.76]
Log	0.00	0.00	2.00	16.25	22.50	0.00
	[0.00-0.95]	[0.00-7.13]	[0.35-10.49]	[9.75-25.84]	[14.73-32.78]	[0.00-11.35]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

Table 20. (continued)

Vegetative cover: mean percent absolute cover [95% confidence intervals]

Elevational zone	I	II	III	IV	V	VI
Total cover	24.75 [20.78-29.20]	76.00 [62.59-85.70]	60.00 [46.18-72.39]	23.75 [15.77-34.14]	30.00 [21.07-40.77]	23.33 [11.79-40.92]
Horsetails	6.75 [4.68-9.64]	58.00 [44.24-70.62]	52.00 [38.51-65.20]	12.50 [6.93-21.50]	1.25 [0.22-6.74]	0.00 [0.00-11.35]
Sedges-Rushes	4.25 [2.67-6.70]	0.00 [0.00-7.13]	0.00 [0.00-7.13]	0.00 [0.00-4.58]	0.00 [0.00-4.58]	0.00 [0.00-11.35]
Grass	14.50 [11.39-18.29]	16.00 [8.34-28.51]	10.00 [4.35-21.36]	8.75 [4.35-16.98]	15.00 [8.80-24.41]	0.00 [0.00-11.35]
Forbs	1.75 [0.85-3.57]	12.00 [5.62-23.80]	24.00 [14.30-37.41]	12.50 [6.93-21.50]	7.50 [3.48-15.41]	10.00 [3.46-25.62]
Woody perennials						
Tamarisk	2.00 [1.02-3.90]	12.00 [5.62-23.80]	0.00 [0.00-7.13]	0.00 [0.00-4.58]	0.00 [0.00-4.58]	0.00 [0.00-11.35]

Vegetation density: mean number of plants per square meter [95% confidence intervals]

	I	II	III	IV	V	VI
Forbs	22.75 [21.32-24.28]	15.40 [12.32-19.24]	22.00 [18.26-26.51]	13.75 [11.41-16.57]	2.75 [1.82-4.16]	0.00 [0.00-1.28]
Woody perennials						
Tamarisk	1.47 [1.14-1.90]	0.20 [0.04-1.13]	0.00 [0.00-0.77]	0.00 [0.00-0.48]	0.00 [0.00-0.48]	0.00 [0.00-1.28]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

Table 21.

Plant Species List: Harp Falls (Transects 25, 26)

Horsetails	Equisetum laevigatum A. Br.
Sedges & Rushes	Eleocharis macrostachya Britt. Juncus balticus Engelm Juncus filiformis L. Juncus longistylis Torr. Scirpus americanus Pers.
Grasses	Agropyron repens (L.) Beauv. Agrostis alba L. cf. Bromus sp. Deschampsia caespitosa (L.) Beauv. Distichlis stricta (Torr.) Rydb. Echinochloa crusgalli (L.) Beauv. Elymus sp. Muhlenbergia asperifolia (Nees & Mey.) Parodi Oryzopsis hymenoides (R. & S.) Ricker cf. Poa Sporobolus cryptandrus (Torr.) A. Gray unid. Gramineae
Forbs	Aster hesperinus Gray var. hesperinus Chrysopsis villosa (Pursh) Nutt. Medicago lupilina L. Polygonum lapathifolium L. cf. Potentilla sp. Ranunculus cymbalaria Pursh. var. saximontanus Fern. Selloa glutinosa Spreng. cf. Umbelliferae cf. Veronica sp.
Woody Perennials	Artemisia ludoviciana Nutt. Tamarix pentandra Pall.

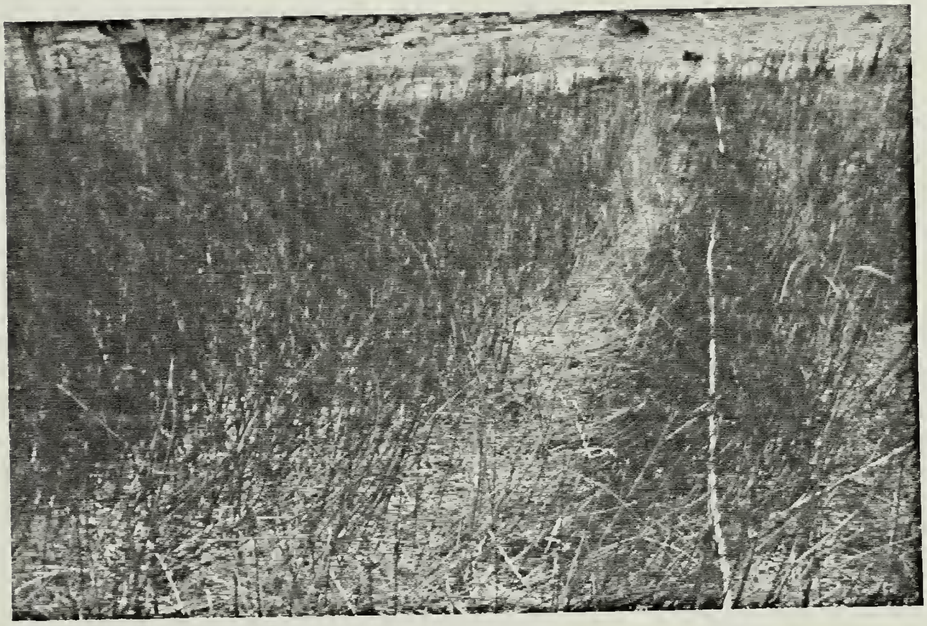


Fig. 43. This dense stand of Equisetum laevigatum dominated the upper zones of the transects at Harp Falls.

Rippling Brook

Prior to completion of Flaming Gorge Dam, the gravel island above Rippling Brook was probably completely covered with water during the spring flood period. Now, as at Kolb Campground, the top of the island is dry year-round. The vegetation of the top is primarily xerophytic, being dominated by *Chrysopsis villosa*, but also containing *Chrysothamnus viscidiflorus* and small specimens of Utah juniper (Fig. 44, Tables 22 and 23).

Grasses were the dominant herbaceous plants near the water. Coverage was higher on the inner slope than the outer, possibly due to greater stoniness along the outer shoreline.

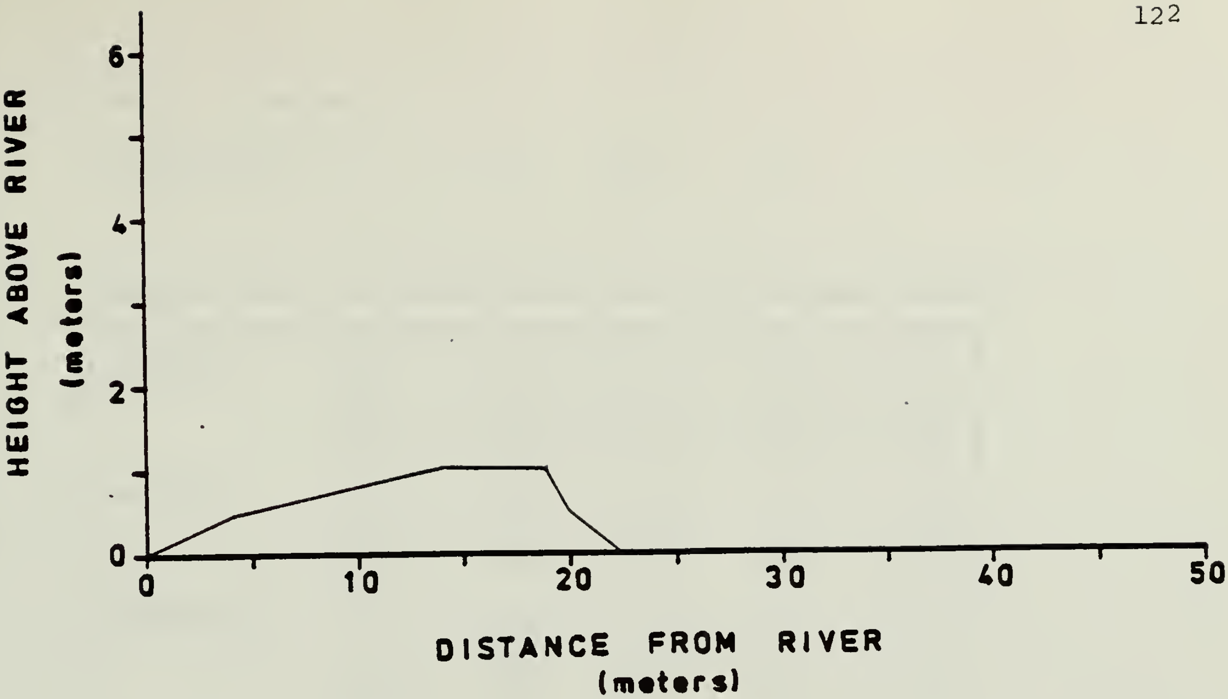


Fig. 44. Representative relief profile for Rippling Brook sampling location. Dashed line represents the floodline.

Table 22. Summary of substrates and vegetation coverage and density for Rippling Brook (upper Green) sampling location.

Substrate: mean percent [95% confidence intervals]

Elevation zone	I	II	III	II	I
Fines		N	O N	E	
Sand	51.00 [41.35-60.58]	21.54 [16.98-26.93]	6.00 [2.06-16.21]	21.76 [16.22-28.55]	67.50 [52.02-79.91]
Rock	49.00 [39.42-58.65]	11.92 [8.53-16.43]	42.00 [29.38-55.76]	2.94 [1.26-6.70]	0.00 [0.00-8.76]
Litter	0.00 [0.00-3.70]	66.15 [60.20-71.63]	52.00 [38.51-65.20]	74.71 [67.68-80.64]	32.50 [20.09-47.98]
Log	0.00 [0.00-3.70]	0.38 [0.07-2.15]	0.00 [0.00-7.13]	0.00 [0.00-2.21]	0.00 [0.00-8.76]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

Table 22. (continued)

Elevational zone	I	II	III	II	I

Vegetative cover: mean percent absolute cover [95% confidence intervals]

Total cover	26.00	36.92	68.00	35.29	65.00
	[18.41-35.37]	[31.29-42.94]	[54.19-79.24]	[28.51-42.73]	[49.51-77.86]
Horsetails	0.00	0.38	2.00	1.76	10.00
	[0.00-3.70]	[0.07-2.15]	[0.35-10.49]	[0.60-5.06]	[3.96-23.05]
Sedges-Rushes	0.00	4.62	0.00	6.47	12.50
	[0.00-3.70]	[2.66-7.89]	[0.00-7.13]	[3.65-11.21]	[5.46-26.11]
Grasses	9.00	13.08	4.00	18.24	25.00
	[4.81-16.22]	[9.51-17.72]	[1.10-13.46]	[13.16-24.72]	[14.19-40.19]
Forbs (all)	4.00	15.77	62.00	10.59	10.00
	[1.57-9.84]	[11.84-20.69]	[48.15-74.14]	[6.80-16.11]	[3.96-23.05]
G-A-A*	0.00	0.00	2.00	2.35	5.00
	[0.00-3.70]	[0.00-1.46]	[0.35-10.49]	[0.92-5.89]	[1.38-16.50]
Woody perennials	6.00	4.42	0.00	0.00	0.00
	[3.47-10.19]	[2.96-6.55]	[0.00-3.70]	[0.00-1.12]	[0.00-4.58]
Willow	9.00	0.00	0.00	0.00	0.00
	[4.81-16.22]	[0.00-1.46]	[0.00-7.13]	[0.00-2.21]	[0.00-8.76]
Tamarisk	3.00	4.62	0.00	0.00	0.00
	[1.03-8.45]	[2.66-7.89]	[0.00-7.13]	[0.00-2.21]	[0.00-8.76]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

* A sub-group of forbs: Glycyrrhiza, Apocynum, and Asclepias.

Table 22. (continued)

Vegetative density: mean number of plants per square meter [95% confidence intervals]

Elevational zone	I	II	III	II	I
Forbs (all)	14.40	90.92	17.60	101.18	30.50
	[12.23-16.95]	[87.33-94.66]	[14.29-21.68]	[96.51-106.47]	[25.55-36.41]
G-A-A *	0.00	0.00	4.40	1.94	8.25
	[0.00-0.38]	[0.00-0.15]	[2.91-6.66]	[1.38-2.73]	[5.88-11.58]
Woody perennials					
Willow	2.20	0.04	0.00	0.00	0.00
	[1.45-3.33]	[0.01-0.22]	[0.00-0.77]	[0.00-0.23]	[0.00-0.96]
Tamarisk mature	0.20	0.65	0.00	0.65	0.00
	[0.05-0.73]	[0.41-1.05]	[0.00-0.77]	[0.36-1.18]	[0.00-0.96]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

* A sub-group of forbs: Glycyrrhiza, Apocynum, and Asclepias.

Table 23.

Plant Species List: Rippling Brook (Transects 27, 28)

Horsetails	*Equisetum arvense* L.
	Equisetum laevigatum A. Br.
Sedges & Rushes	*Juncus balticus* Engelm.
Grasses	*Agrostis alba* L.
	Agropyron repens (L.) Beauv.
	Agropyron trachycaulum (Link) Malte
	Bromus inermis Leyess.
	Calamagrostis scopulorum Jones
	Distichlis stricta (Torr.) Rudb.
	Elymus canadensis L.
	Muhlenbergia asperifolia (Nees & Mey.) Parodi
	Muhlenbergia racemosa (Michx.) B.S.P.
	Oryzopsis hymenoides (R. & S.) Ricker
	Spartina sp.
	Sporobolus cryptandrus (Torr.) A. Gray
	unid. Gramineae
Forbs	*Apocynum cannabinum* var. *glaberrimum* A. DC.
	Aster hesperinus Gray var. *hesperinus*
	Brickellia scabra (Gray) A. Nels.
	Chrysopsis villosa (Pursh) Nutt.
	Grindelia sp.
	Mentha arvensis L.
	Polygonum lapathifolium L.
	cf. *Potentilla* sp.
	Selloa glutinosa Spreng.
Woody Perennials	*Artemisia ludoviciana* Nutt.
	Chrysothamnus nauseosus subsp. *bigelovi* (Gray) H. & C.
	cf. *Chrysothamnus viscidiflorus*
	Salix exigua Nutt.
	Tamarix pentandra Pall.

Limestone Draw

The sandy beach at Limestone Draw also follows the general pattern of the sites described above (Fig. 45, Tables 24 and 25). The highest plant coverage was in Zones II and III, primarily due to grasses. Equisetum laevigatum became important from Zone III to V.

Forbs dominated the vegetation near the water's edge. These were primarily wetland species, capable of growing in saturated soil and surviving periodic inundation. These included Ranunculus cymbalaria, Polygonum lapathifolium, Potentilla sp., and Plantago major. The importance of these forbs at Limestone compared to the other Green River sites may in part be due to a relatively low river stage at the time this site was sampled. These species may have been present, but under water, and hence not sampled, at other sampling locations on this river corridor. This kind of sampling problem is an oddity of the marked daily fluctuation of water level on the upper Green. The presence of submerged forbs along the Green River is shown in Fig. 46.

Woody perennials at Limestone Draw were principally tamarisk and boxelder, the former near the water's edge and the latter dominating the area above the old floodline.

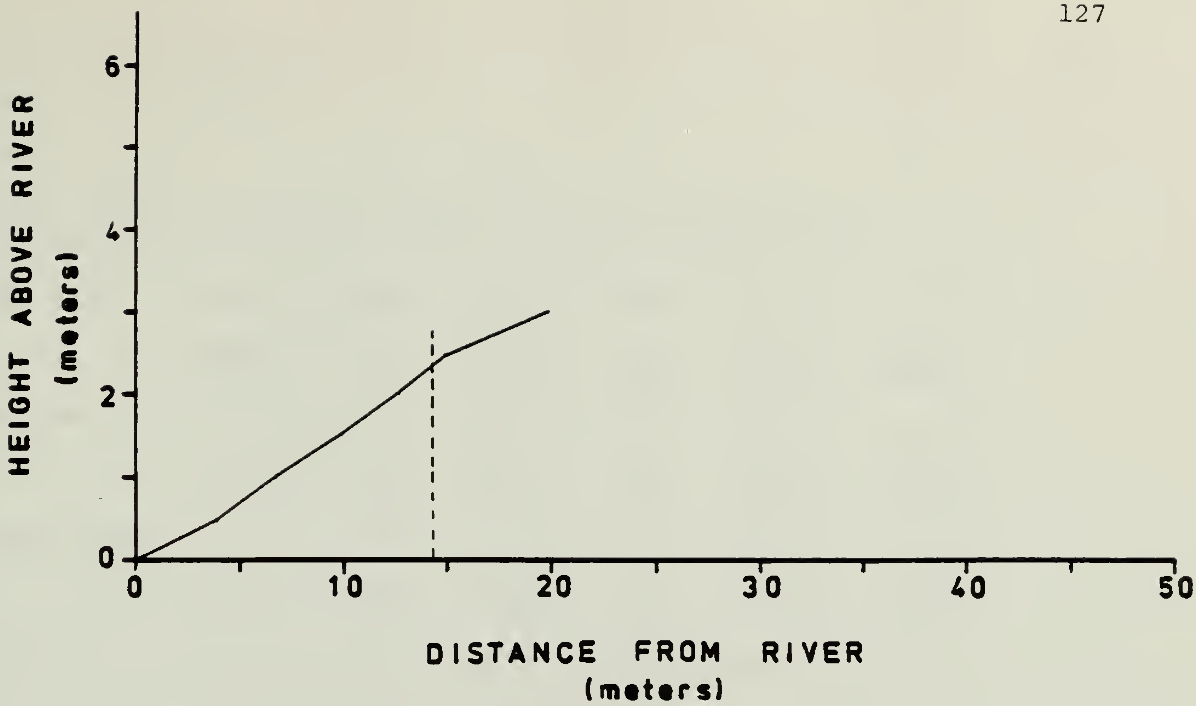


Fig. 45. Representative relief profile for Limestone sampling location. Dashed line represents the floodline.

Table 24. Summary of substrates and vegetation coverage and density for Limestone (Green) sampling location.

Elevational zone	I	II	III	IV	V	VI
Substrate: mean percent [95% confidence intervals]						
Fines		N	O	N	E	
Sand	75.39	24.00	0.00	0.00	0.00	0.00
	[67.32-81.99]	[16.69-33.23]	[0.00-6.02]	[0.00-4.09]	[0.00-8.76]	[0.00-3.37]
Rock	13.08	0.00	0.00	0.00	0.00	0.00
	[8.33-19.94]	[0.00-3.40]	[0.00-6.02]	[0.00-4.09]	[0.00-8.76]	[0.00-3.37]
Litter	11.54	76.00	100.00	100.00	100.00	100.00
	[7.12-18.16]	[66.77-83.31]	[93.98-100.00]	[95.91-100.00]	[91.24-100.00]	[96.63-100.00]
Log		N	O	N	E	

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

Table 24. (continued)

Vegetative cover: mean percent absolute cover [95% confidence intervals]

Elevational zone	I	II	III	IV	V	VI
Total cover	46.92 [38.56-55.46]	78.00 [68.93-84.99]	81.67 [70.08-89.44]	45.56 [35.66-55.81]	52.50 [37.50-67.06]	40.00 [31.33-49.34]
Horsetails	0.00 [0.00-2.87]	10.00 [5.52-17.44]	25.00 [15.78-37.23]	14.44 [8.64-23.16]	20.00 [10.50-34.75]	10.00 [5.68-17.02]
Sedges & Rushes	0.77 [0.14-4.23]	8.00 [4.11-15.00]	0.00 [0.00-6.02]	0.00 [0.00-4.09]	0.00 [0.00-8.76]	0.00 [0.00-3.37]
Grass	12.31 [7.72-19.00]	37.00 [28.18-46.78]	48.33 [36.18-60.69]	8.89 [4.57-16.57]	20.00 [10.50-34.75]	16.36 [10.61-24.39]
Forbs	47.69 [39.30-56.22]	31.00 [22.78-40.62]	11.67 [5.77-22.18]	12.22 [6.96-20.57]	0.00 [0.00-8.76]	0.00 [0.00-3.37]
Woody perennials (all)	0.77 [0.14-4.23]	26.00 [18.41-35.37]	31.67 [21.31-44.23]	20.00 [13.64-28.80]	27.50 [16.11-42.83]	15.46 [9.88-23.36]
Tamarisk	0.77 [0.14-4.23]	26.00 [18.41-35.37]	31.67 [21.31-44.23]	0.00 [0.00-4.09]	0.00 [0.00-8.76]	0.00 [0.00-3.37]
Box elder	0.00 [0.00-2.87]	0.00 [0.00-3.40]	0.00 [0.00-6.02]	20.00 [13.64-28.80]	27.50 [18.00-41.25]	15.45 [9.55-23.22]

Vegetative density: mean number of plants per square meter [95% confidence intervals]

	I	II	III	IV	V	VI
Forbs	54.54 [50.67-58.70]	36.50 [32.94-40.44]	18.33 [15.21-22.09]	15.89 [13.49-18.71]	0.00 [0.00-0.96]	0.00 [0.00-0.35]
Woody perennials						
Tamarisk	0.00 [0.00-0.30]	0.10 [0.02-0.57]	0.00 [0.00-0.64]	0.00 [0.00-0.43]	0.00 [0.00-0.96]	0.00 [0.00-0.35]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

Table 25.

Plant Species List: Limestone (Transects 29, 30, 31)

Horsetails	Equisetum arvense L.
	Equisetum laevigatum A. Br.
Sedges & Rushes	Eleocharis macrostachya Britt.
	Juncus balticus Engelm.
	Juncus filiformis L.
Grasses	Agropyron pseudorepens Scribn.
	Agropyron smithii Rydb.
	Agropyron trachycaulum (Link) Malte
	Agrostis alba L.
	Deschampsia caespitosa (L.) Beauv.
	Distichlis stricta (Torr.) Rydb.
	Elymus canadensis L.
	Muhlenbergia racemosa (Michx.) B.S.P.
	Polypogon monspeliensis (L.) Desf.
	Sporobolus cryptandrus (Torr.) A. Gray
	Stipa comata Trin. & Rupr. var. comata
Forbs	cf. Amaranthus sp.
	Apocynum cannabinum var. glaberrimum A. DC.
	Chrysopsis villosa (Pursh) Nutt.
	cf. Cicuta sp.
	unk. Compositae (two types)
	Grindelia squarrosa (Pursh) Dunal var. squarrosa
	Melilotus officinalis (L.) Lam.
	Mentha arvensis L.
	Plantago major L.
	Polygonum sp.
	Polygonum lapathifolium L.
	cf. Potentilla
	Ranunculus cymbalaria Pursh var. saximontanus Fern.
	cf. Rumex sp.
	Selloa glutinosa Spreng.
Woody Perennials	Acer negundo L.
	Artemisia ludoviciana Nutt.
	Chrysothamnus nauseosus subsp. graveolens (Nutt.) H. & C.
	Tamarix pentandra Pall.

Summary: the Upper Green

Scattered tamarisk plants were a common feature of all four sample sites as well as the rest of the canyon. Twelve of these plants from two locations were cut and aged. The results are shown in Fig. 47. All of the plants were older than those aged at Big Joe on the Yampa. Two peaks, each representing one-third of the entire sample, were found. The first peak was in 1963, the year Flaming Gorge Dam was completed. The second was in 1965. No plants were dated from the intervening year. Two plants were found to pre-date the dam, indicating that tamarisk was already established on the Green River prior to flow regulation. Both of these plants were found above the old floodline at the Wild Mountain sampling site. A very large tamarisk plant was also observed here having a trunk diameter of approximately 20 cm. Although it was not cut, this plant must also have pre-dated the dam.

Flow data from Greendale, Utah, recorded during the early 1960s, reveal a possible relationship between tamarisk establishment within the floodzone and flow regulation. In 1962, the last year with an unregulated spring flow, tamarisk seedling establishment may have been similar to that observed on the Yampa. In the next year, the flood gates were closed and the majority of the flow was retained in the reservoir. From that year onward, the river has not risen high enough to scour away the tamarisk plants from the 1962 seed crop. These individuals may date to 1963 by the ring-counting method, since the first year's growth may have been too low to be discernible in the cross-sections.

The absence of stems from 1964, and a second peak in 1965, are difficult to explain with the available data. The apparent dependence of tamarisk on flood conditions for successful seedling establishment makes it more likely that stems dated after 1963 originated as sprouts instead of directly from seedlngs. The

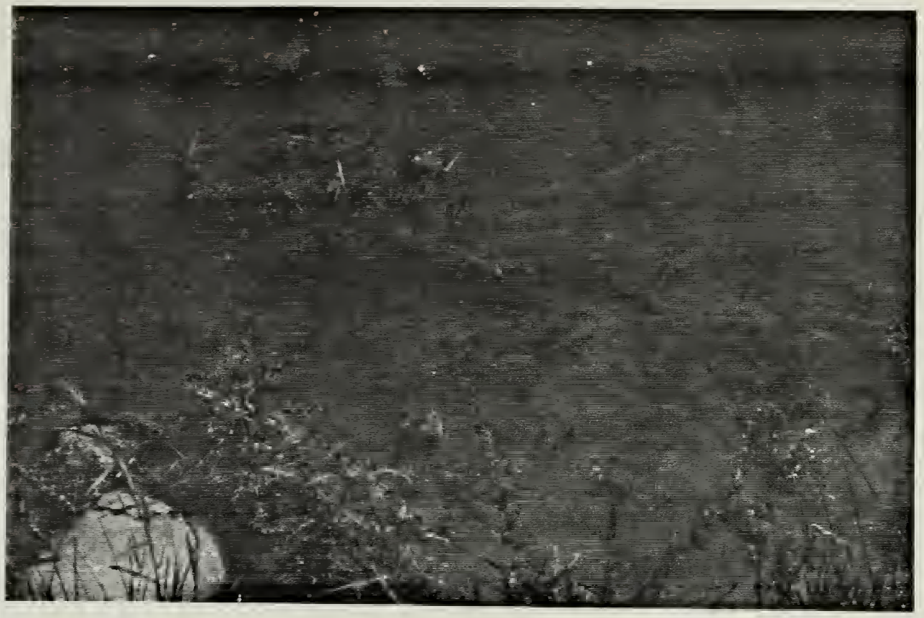


Fig. 46. The water of the Green River is relatively clear. Plants along the shoreline, as shown here, are able to survive the short periods of inundation in this water with no signs of damage from sediments or physiological stress.

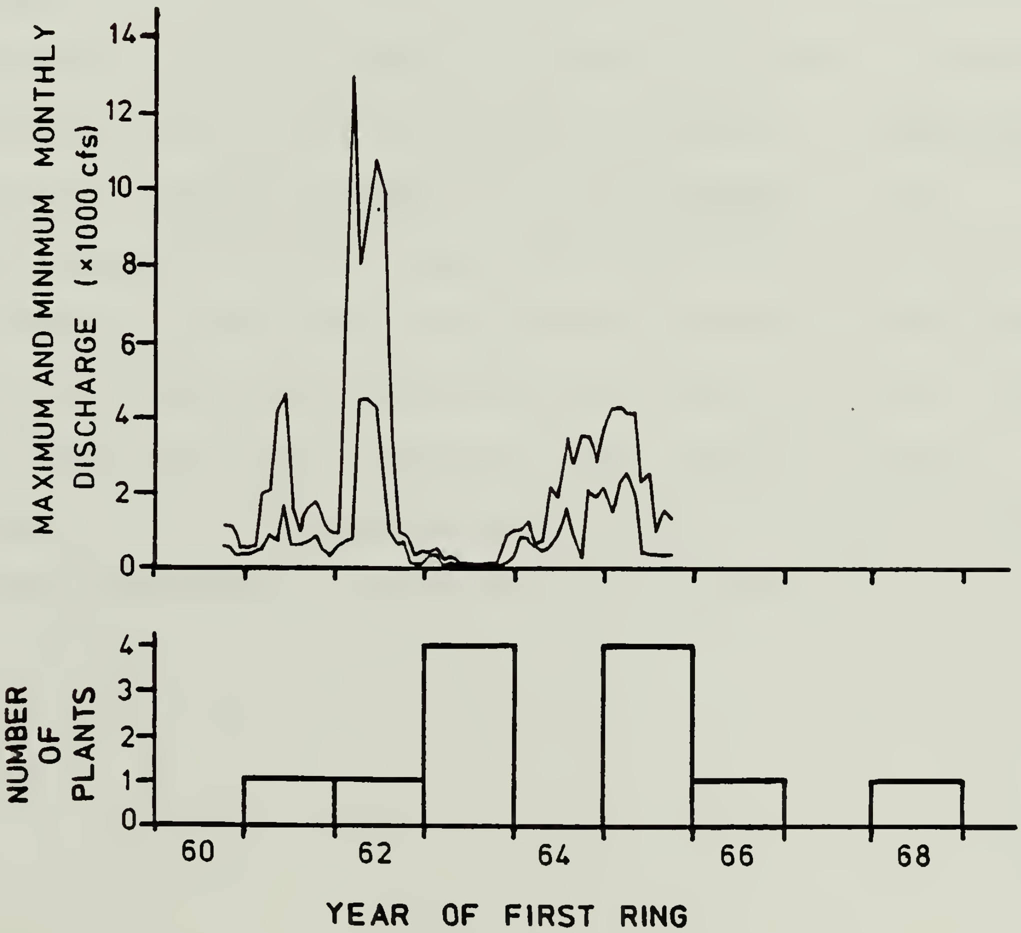


Fig. 47. Tamarisk stem ages from two sites in the Canyon of Lodore with discharge on the Green River.

pattern observed may have been created by the inhibition of sprouting by low water levels in the previous year and sprout stimulation the year after water levels were raised. Although much of this interpretation is speculative, the fact that none of the plants found below the old floodline pre-date flow regulation, and that 80% of these plants date within the first three years of regulation, strongly implicate flow regulaton as the primary factor affecting production of the tamarisk stands observed through Lodore Canyon. This is further supported by the historical photographs (Figs. 48-57). Pre-dam photographs show a floodzone free of tamarisk, while many of the reshots exhibit tamarisk stands.

The floodzone of the pre-dam photos appears to have been very similar to that of the Yampa. Invasion of this area by riparian and upland vegetation has been significant. In addition to tamarisk, boxelder and juniper have also become established in the old floodzone. Of particular interest in the post-dam photographs are the dense growths of rhizomatous species such as Glycyrrhiza lepidota (Fig. 58), Phragmites communis (Fig. 59), Agropyron sp., and Equisetum sp. along the shoreline. These growths appear to be altering the bank morphology of the river where they occur by the slow process of growing into the river channel and accumulating sediments around the base of the plant. Over time, this process could produce a narrowed, deeper channel with steep, stabilized banks. Graf (1978) predicted such a change as a result of tamarisk invasion in the lower sections of the Colorado River system.

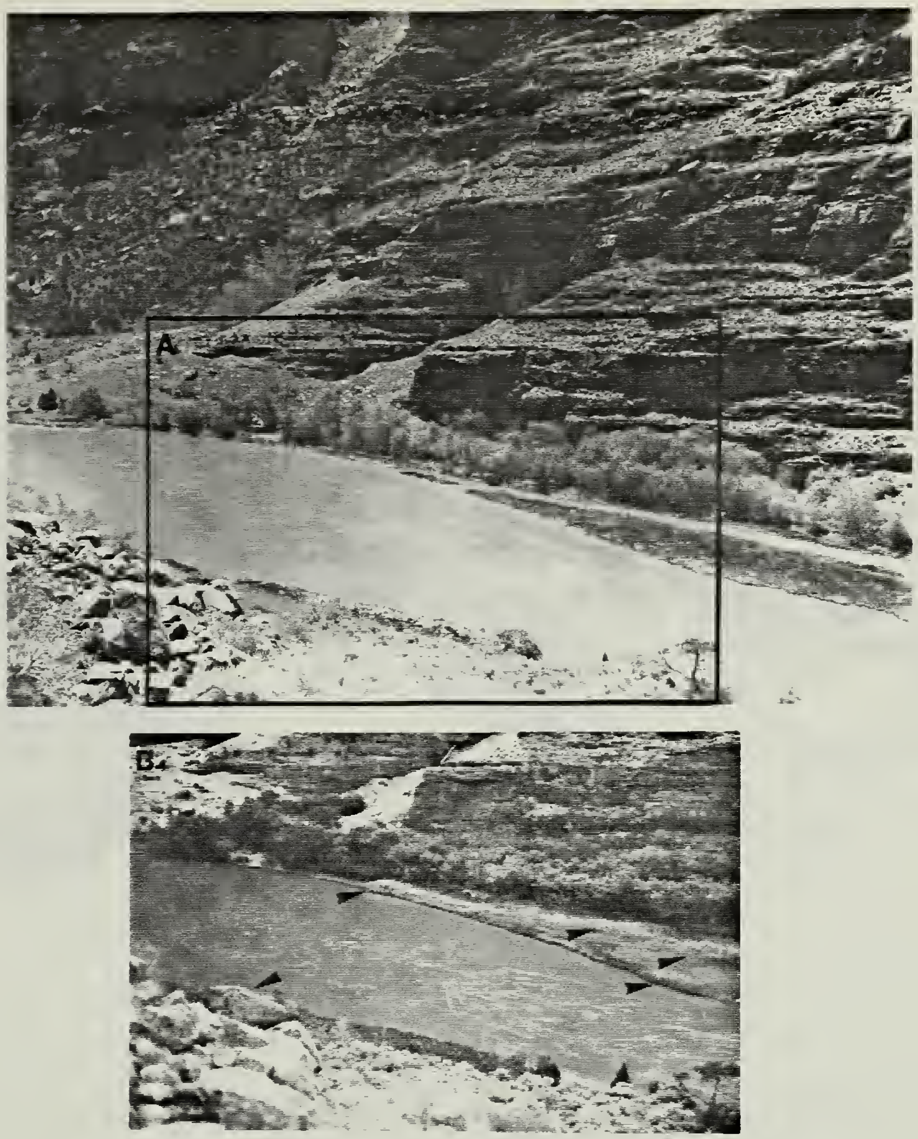


Fig. 48. Green River, Canyon of Lodore, Mile 241. Looking across and slightly downstream at Wade and Curtis campground.
Photo A, 6/72, unknown photographer, DNM D3215 #2258; Photo B, 9/82, Fischer. These photos show the vegetation at Wade and Curtis campground after 9 (Photo A) and 19 (Photo B) years of controlled flow. From A to B there is an apparent shrpening of the definition of the island's outer bank. The arrows point to stands of Phragmites, a species whose litter would be visible in Photo A if the species were present. The top of the island is covered with a dense growth of grasses, along with extensive Phragmites stands, sedges, rushes, and a variety of mesophytic forbs. Today the channel shows no indication of recent flooding.

Fig. 49. Green River, Canyon of Lodore, Mile 242.4. Looking downstream. Photo A, 1871, Beaman & Hillers, U.S.G.S.; Photo B, 1969, Shoemaker & Stephens, U.S.G.S.; Photo C, 1982, Fischer.

In Photo B, note that the sand bar (Photo A) has completely eroded away, as has the sand bank on the opposite shore. What remained in 1969 (Photo B) was a sand and stone bank with stone armoring along the shoreline and a stand of tamarisk mixed with grasses and forbs. Today (Photo C, not the exact location of B) the dense stand of tamarisk, grass, and forbs (notably Asclepias) remain. Note the sparsity of foliage on the tamarisk in both B and C. Though the striking changes illustrated in the century since Photo A cannot definitely be attributed to flow regulation, the implication that this is the case is strong.

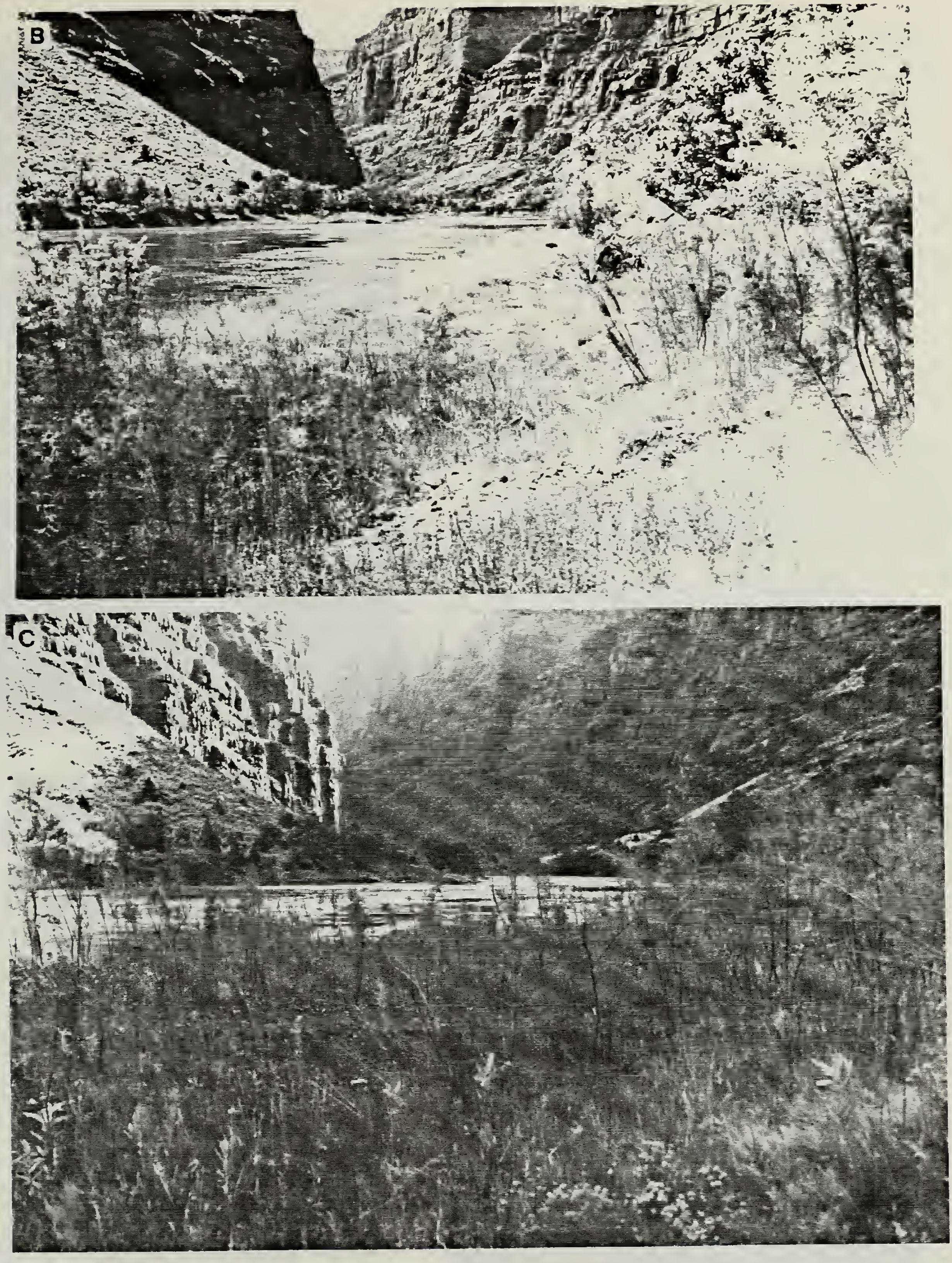


Fig. 49 b,c.

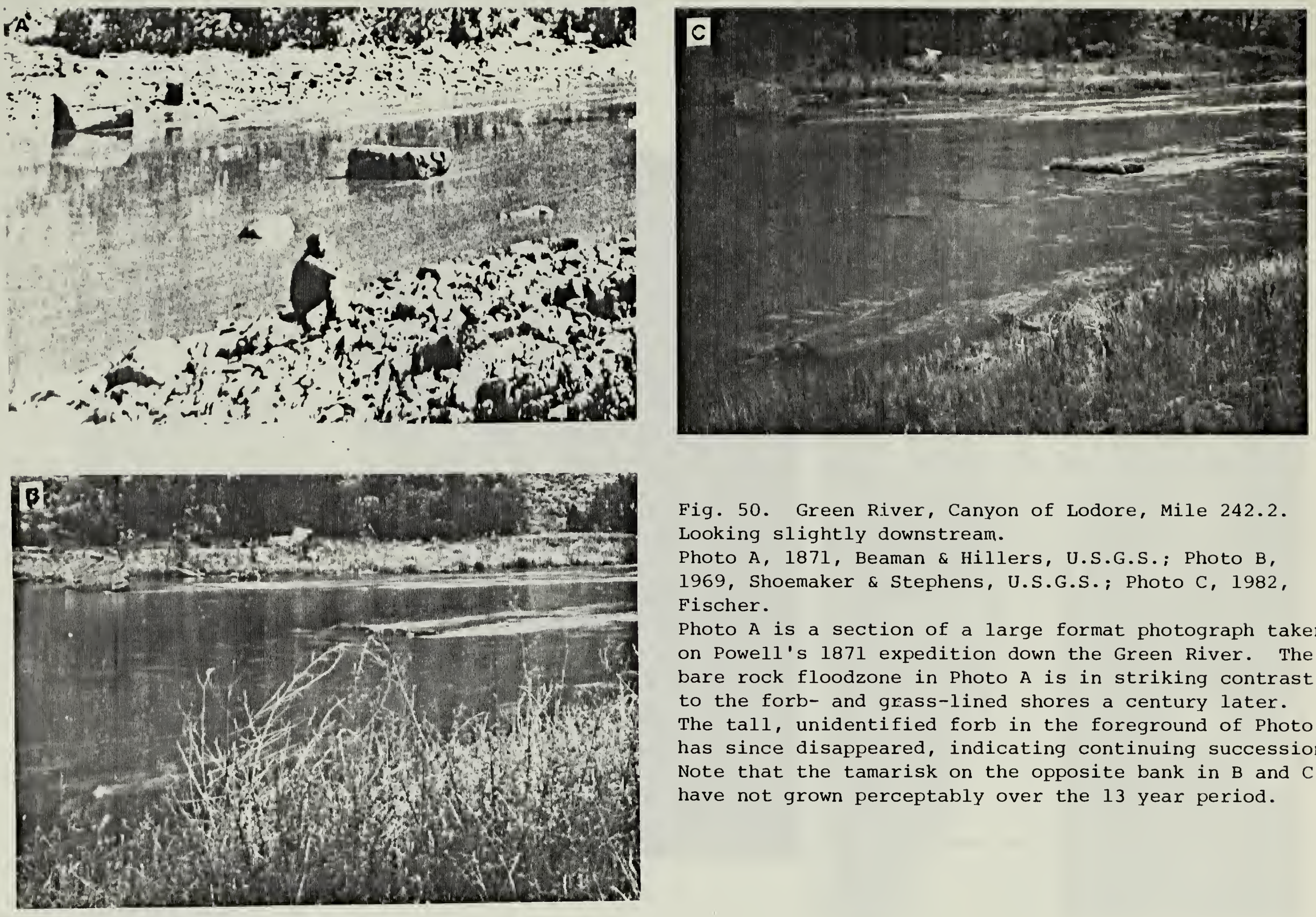
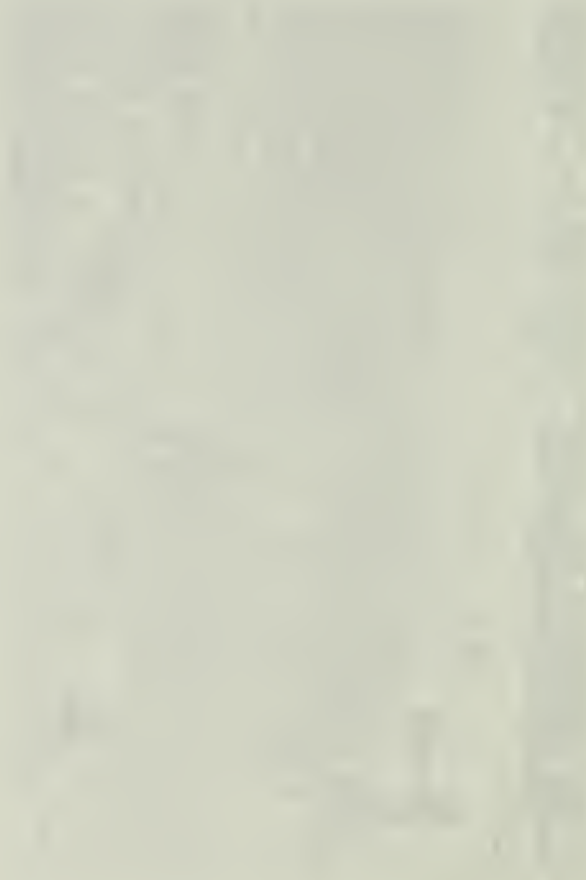


Fig. 50. Green River, Canyon of Lodore, Mile 242.2. Looking slightly downstream.
Photo A, 1871, Beaman & Hillers, U.S.G.S.; Photo B, 1969, Shoemaker & Stephens, U.S.G.S.; Photo C, 1982, Fischer.
Photo A is a section of a large format photograph taken on Powell's 1871 expedition down the Green River. The bare rock floodzone in Photo A is in striking contrast to the forb- and grass-lined shores a century later. The tall, unidentified forb in the foreground of Photo B has since disappeared, indicating continuing succession. Note that the tamarisk on the opposite bank in B and C have not grown perceptably over the 13 year period.



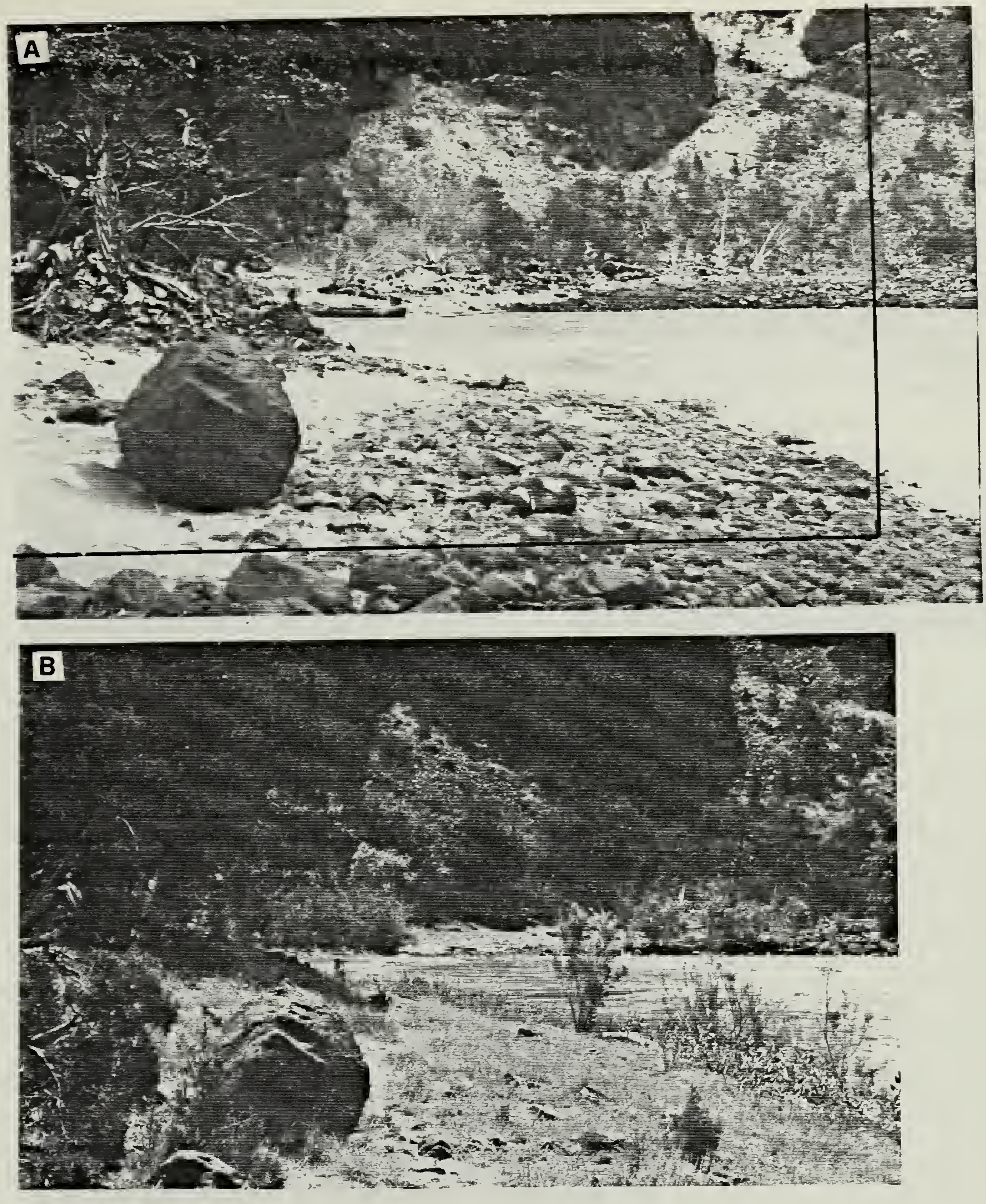
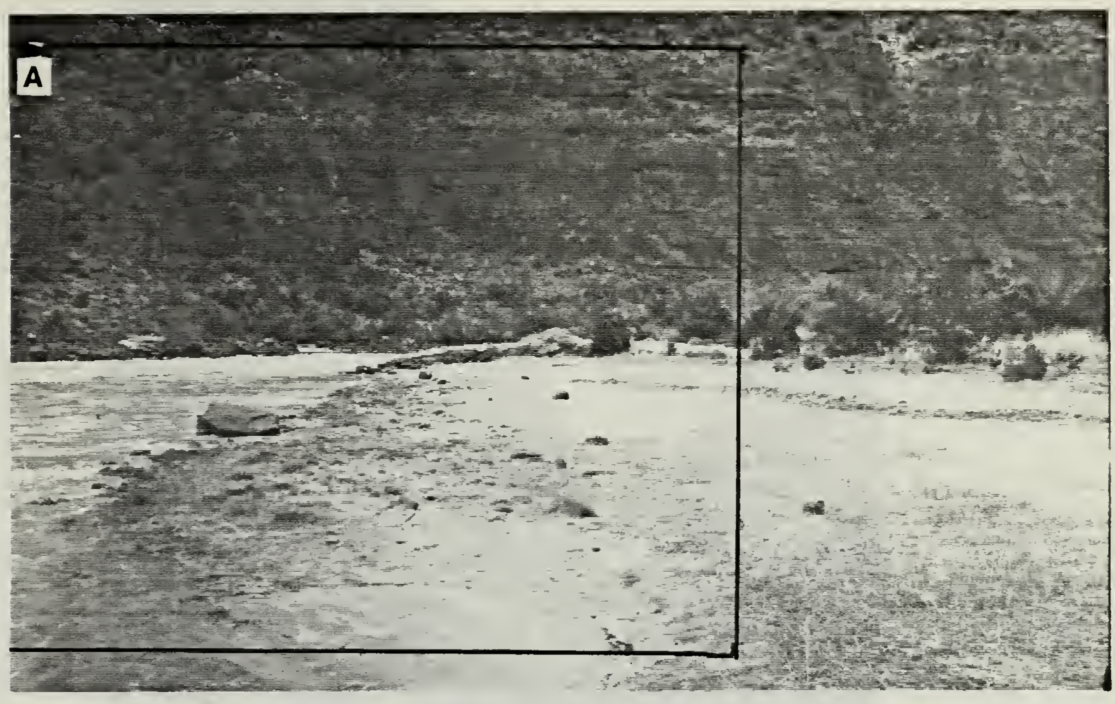


Fig. 51. Green River, Canyon of Lodore, Mile 237.2. Looking across an embayment at the landing above Upper Disaster Falls.
Photo A, 4/5/58, Clemons, DNM D3217 #901; Photo B, 8/11/82, Fischer.
Photo A is one of an excellent series of photographs taken by Clemons, five years before the completion of Flaming Gorge Dam. In Photo B, the previously bare floodzone has been invaded by grasses and forbs from the Pinyon-Juniper community above. Litter accumulation is notable, as well as two young junipers in the old floodzone. The shoreline of B shows some small tamarisks (larger ones in the background), with a band of Asclepias and grasses. The small trees on the shoreline of the opposite bank are boxelder and tamarisk.



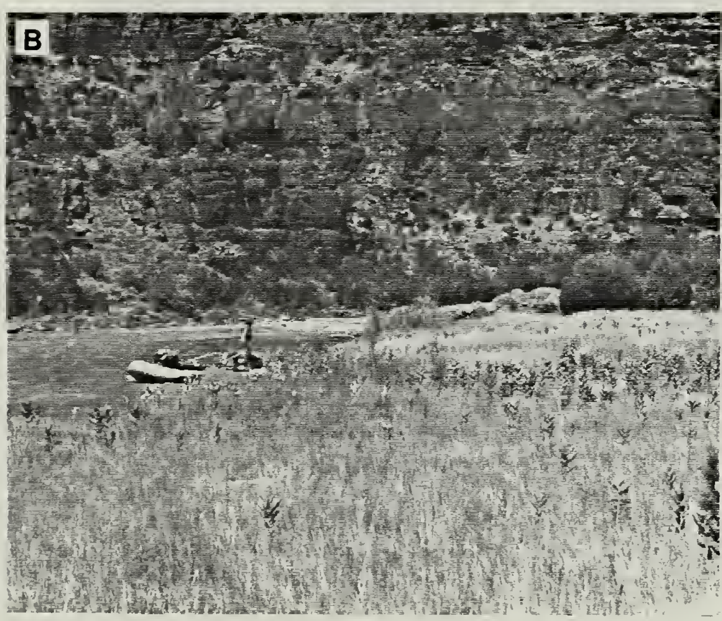


Fig. 52. Green River, Canyon of Lodore, Mile 236.5. Looking upstream toward Upper Disaster Falls.
Photo A, 4/5/58, Clemons, DNM D3217 #904; Photo B, 8/11/82, Fischer.
Grasses appear in the foreground of Photo A, but the effect of scouring on these is obvious. Today the area is covered with a dense growth of Agropyron and Asclepias with a few wispy tamarisk plants intermixed. Of particular interest in Photo B is the steep, stabilized bank which has developed over the past 24 years, replacing the gradual slope of the old floodzone.

A

Fig. 53. Green River, Canyon of Lodore, Mile 234.5. Looking downstream (see Fig. 3).
Photo A, 1871, Beaman & Hillers, U.S.G.S.; Photo B, 1969, Shoemaker & Stephens, U.S.G.S.; Photo C, 1982, Fischer.
Photo A was taken during high runoff, the water reaching the bases of the foreground rocks. Most of the area inundated in Photo A is now exposed year-round (Photos B and C). The old floodzone area now supports a mixture of grasses, sedges, forbs, and small tamarisks. Note that the grass cover has increased notably in the past 13 years, between Photos B and C, but that the tamarisk have neither increased in size or number.

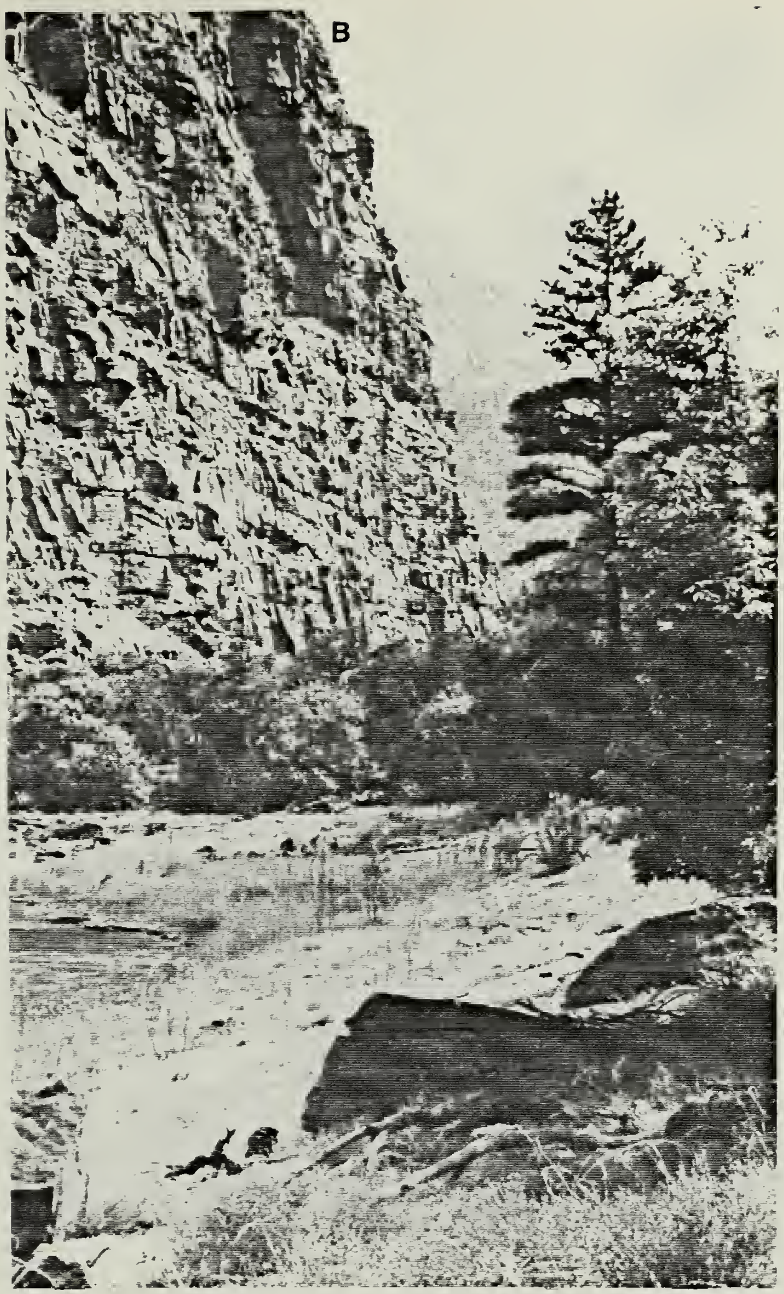


Fig. 53b.

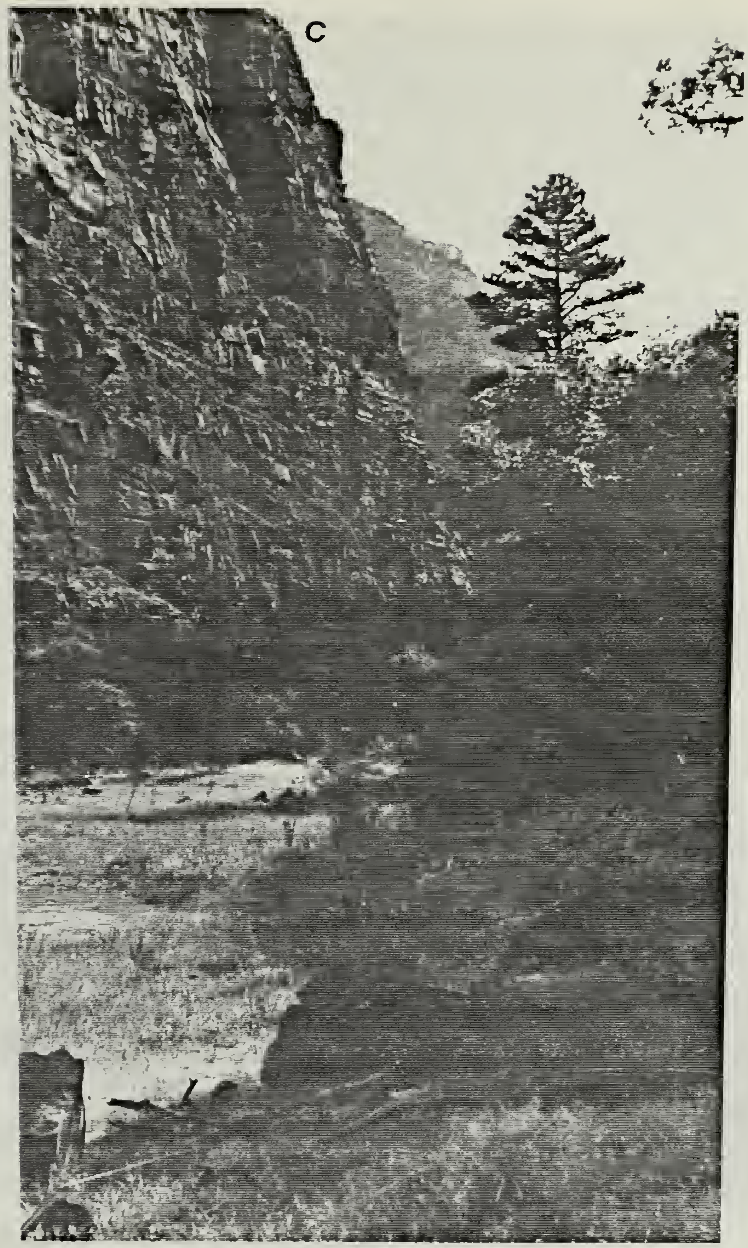
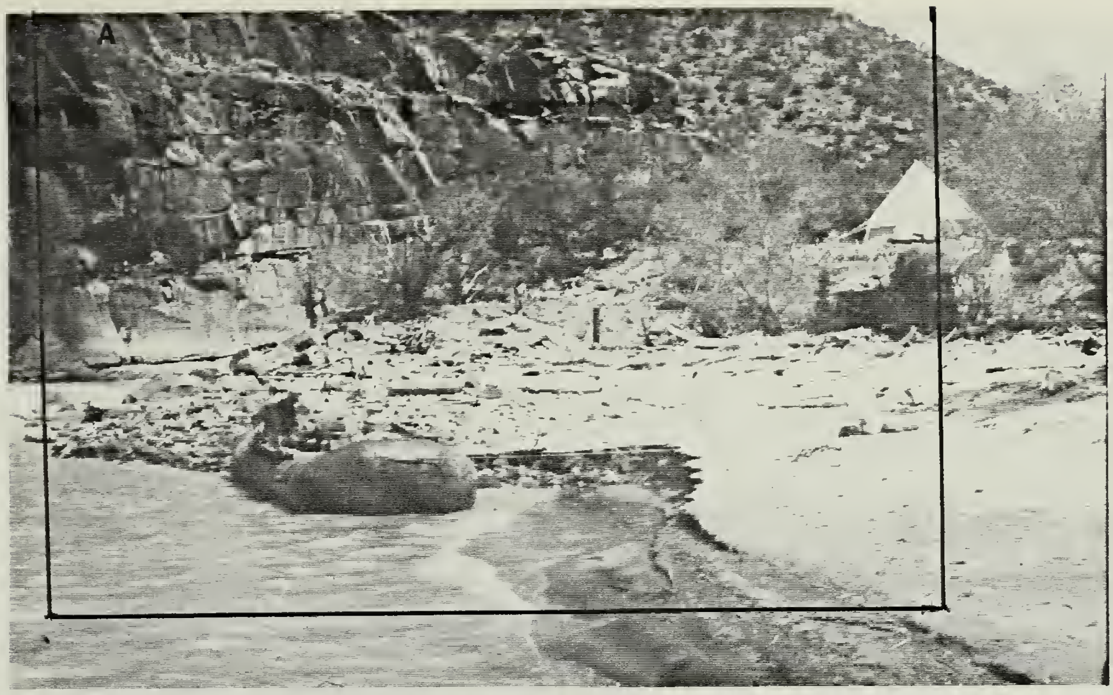


Fig. 53c.



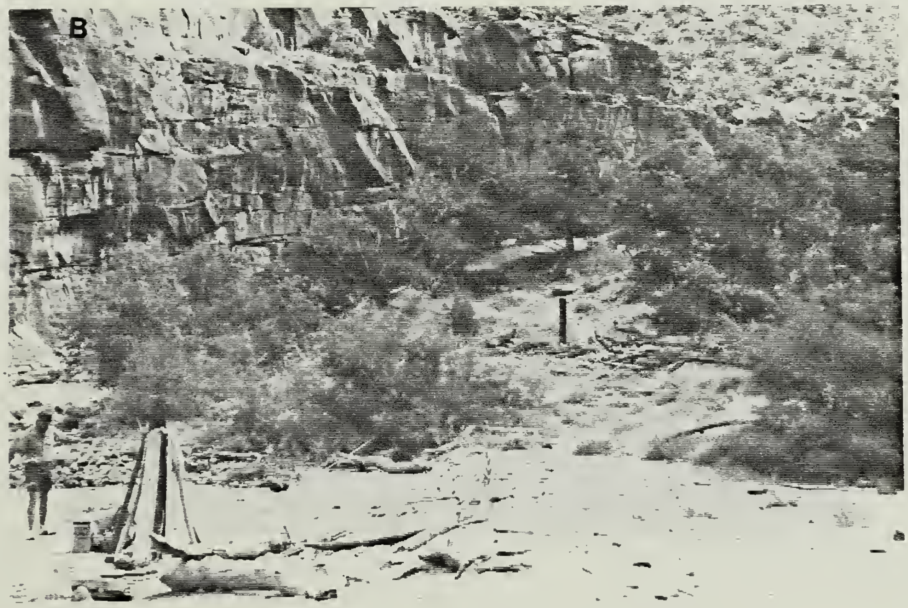
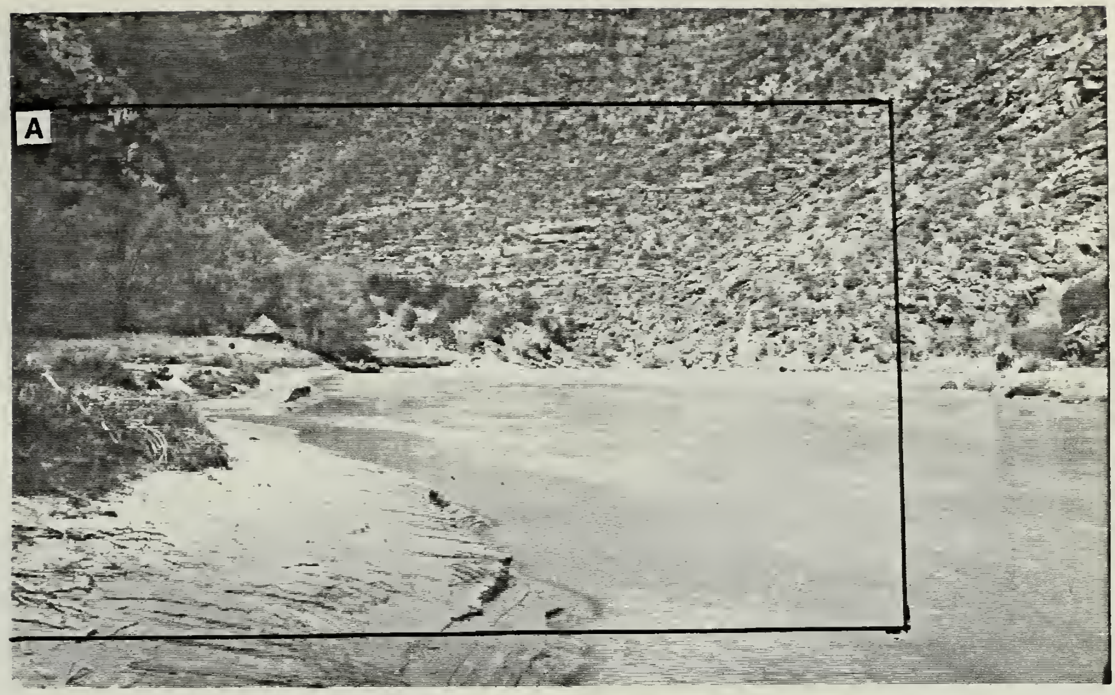


Fig. 54. Green River, Canyon of Lodore, Mile 232.3. Lower end of Triplet Falls, looking upstream.
Photo A, 4/5/58, Clemons, DNM 3217 #908; Photo B, 8/12/82, Fischer.
Photo A illustrates well the pre-dam floodzone of the Green in an area of sand deposition. Note the logs marking the old floodline; these are still evident today (Photo B). The foreground of Photo B is an area heavily used by visitors, and does not represent natural succession of the post-dam vegetation. Note the increased steepness of the slop-leading up to the old floodline, due to erosion of the unstabilized sand. The large shrubby plants in the foreground are tamarisk, established after 1958. Holmgren (1962) predicted that this site would undergo significant changes as a result of controlled flow, due to the dynamic nature of the sandy substrate.



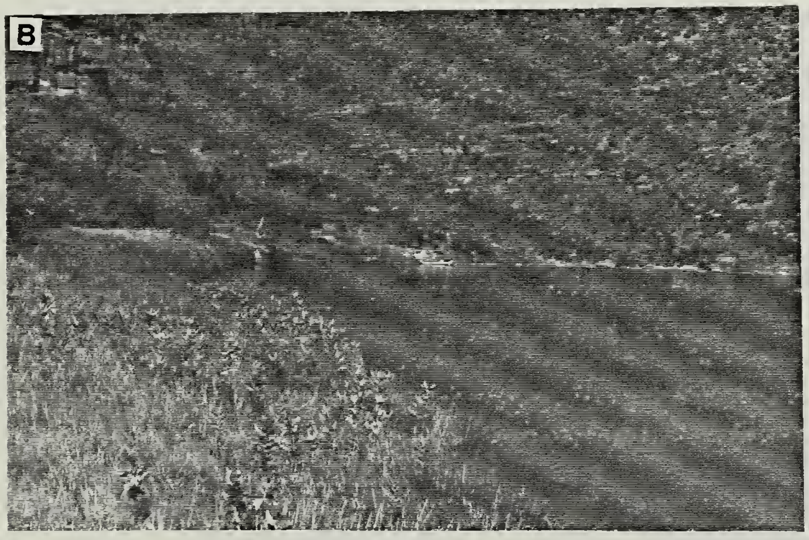


Fig. 55. Green River, Canyon of Lodore, Mile 232. The landing above Hell's Half Mile, looking downstream.
Photo A, 4/5/58, Clemons, DNM 3217 #897; Photo B, 8/12/82, Fischer.
Photo A, taken during relatively low water, reveals a bare and shallowly sloped bank. The scouring effects of periodic spring flooding appear to control the extent to which the dense stands of horsetail on the left are able to move into the floodzone. In Photo B, the effect of flow regulation is seen in the continued process of plant growth and sediment accumulation. Horsetail, milkweed (the large leaved forb in the foreground), and wild licorice (the darker forb in the midground), once released from the scouring effects of spring floods, have created a steep sided, stabilized bank. Continuation of this process could result in growth of this bank farther into the river, narrowing and perhaps deepening the channel.

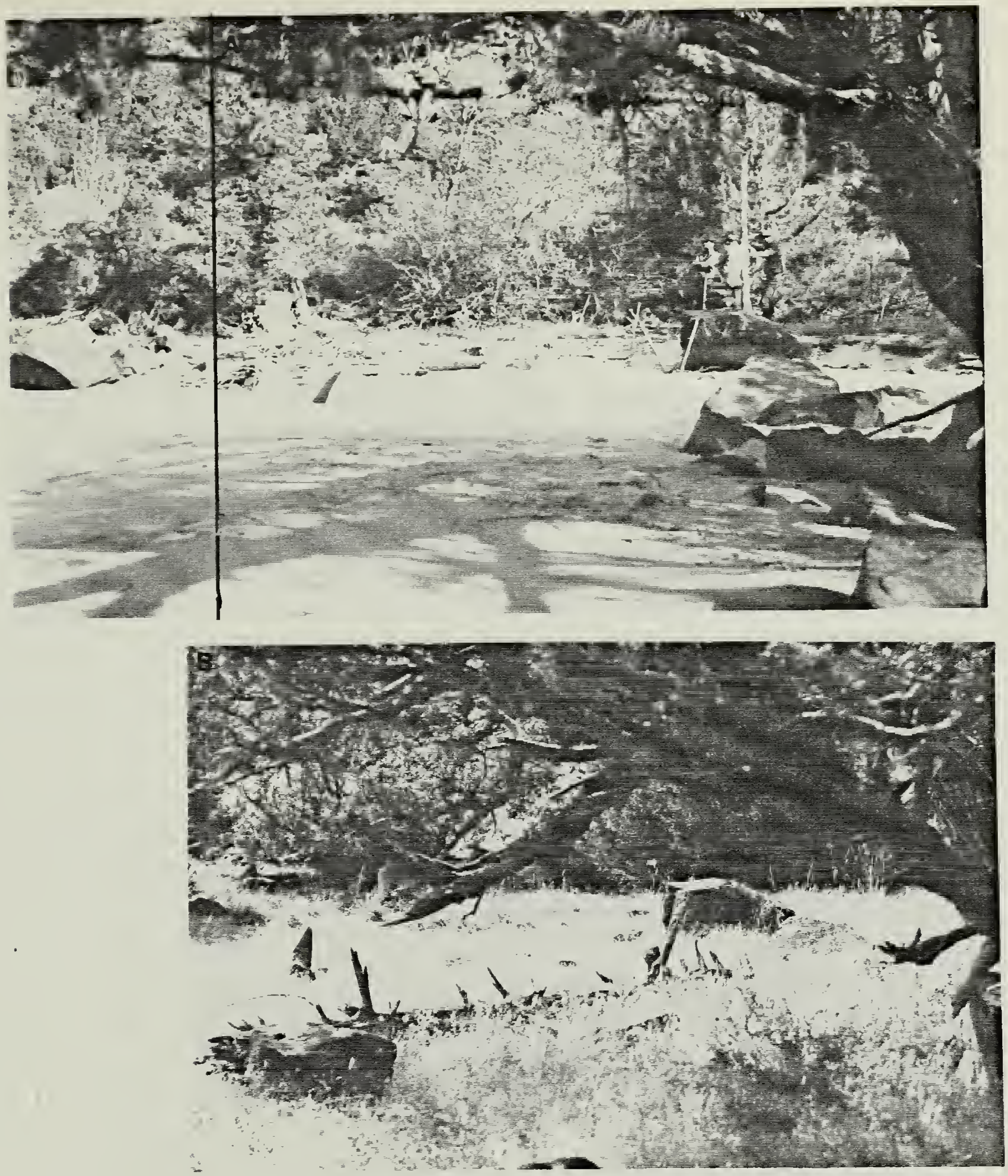


Fig. 56 Green River, Canyon of Lodore, Mile 231.8. Looking upslope on the left bank, at the lower landing of Hell's Half Mile.
Photo A, 4/5/58, Clemons, DNM 3217 #898; Photo B, 8/12/82, Fischer.
Photo A shows clear signs of scouring. Note the water line on the rock in front of the men. Today, the area has been invaded with downy chess, an exotic annual grass which has become a pest species in parts of the Monument. The large juniper branch in the foreground of Photo B has fallen since 1958, forcing us to move the camera station about 2 m from the original location.

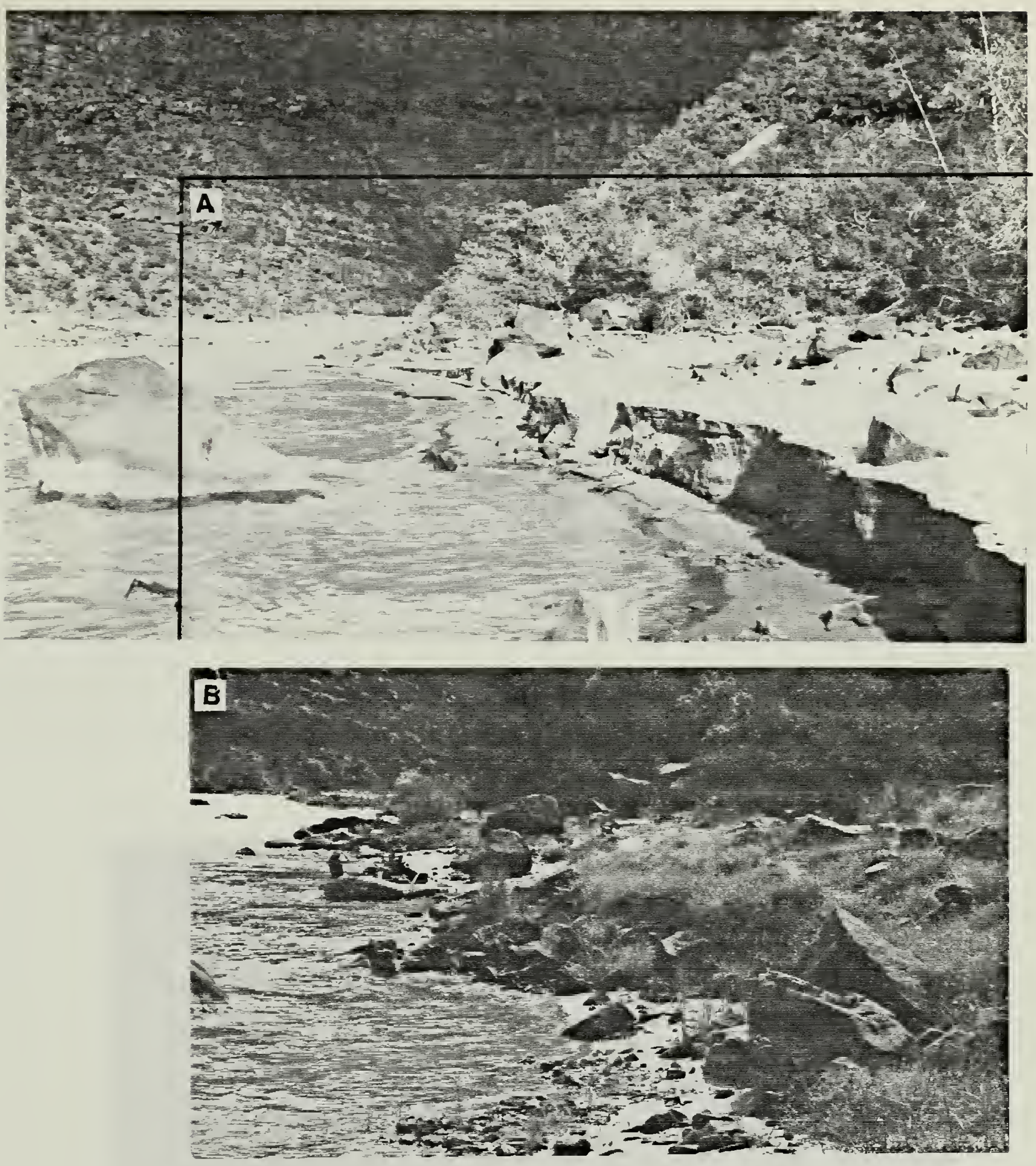


Fig. 57. Green River, Canyon of Lodore, Mile 231.4. Looking upstream at the lower end of Hell's Half Mile.
Photo A, 4/5/58, Clemons, DNM 3217 #900; Photo B, 8/12/82, Fischer.
This pair graphically illustrates the erosion of sand deposits following flow regulation. The remaining sand is stabilized by vegetation and the exposed rocks. Current duning of the sand was observed in some locations.

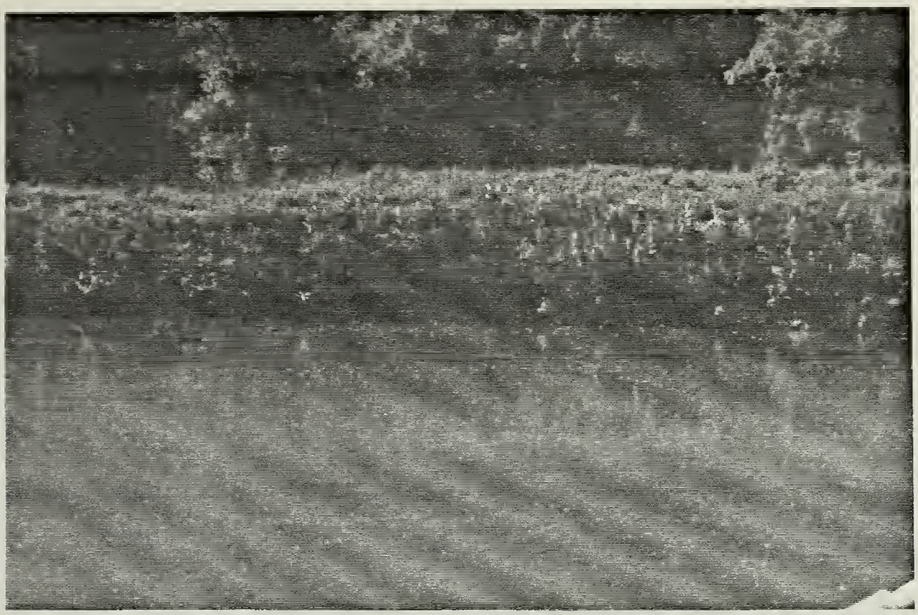


Fig. 58. This is the steep bank at the landing above Hell's Half Mile. The formationof this bank by the growth of Glycyrrhiza is discussed in Fig. 55 and in the text.

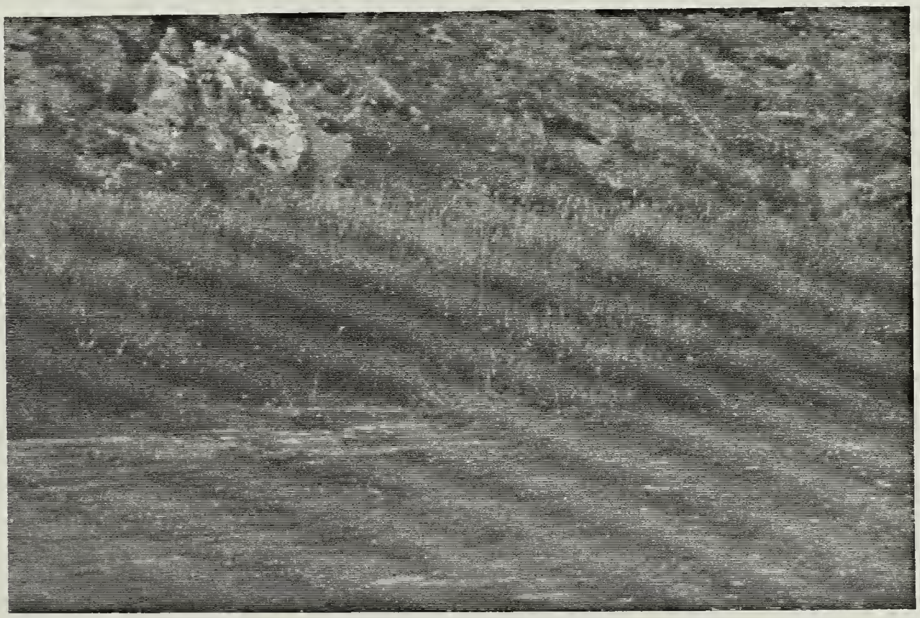


Fig. 59. Phragmites communis is a prominent species along the entire length of Lodore Canyon. As seen here near the confluence with the Yampa, Phragmites, as with Glycyrrhiza, is able to form steep sided banks and slowly expand into the channel by rhizome growth.

The Green River below the Yampa

Stateline and Compromise

The two sites sampled in Whirlpool Canyon (Stateline Campground, Tables 26 and 27 and Fig. 60, and Compromise Campground, Tables 28 and 29, and Fig. 61) can be best characterized as a combination of the vegetational features of both the Yampa river and the Green above the confluence. Zones I and II of both sites are similar to the floodzone of the Yampa River having low total plant coverage, no grasses, and large numbers of tamarisk seedlings. The higher zones were similar to the upper Green in terms of coverage and species composition.

In Zone III, a new floodline was found, produced by the peak flows contributed by the Yampa. The pre-dam floodline was in Zone V. In the intervening area at both sites were found large, vigorous stands of tamarisk. These plants, though not aged, probably share the same origin as those found along the Green above the confluence. The greater size and vigor of these plants may be the result of the seasonal fluctuation in the river flow which annually raises the water table, but does not permanently saturate the root zone. The development of these tamarisk stands can be seen in the photo pair from Harper's Corner (Fig. 62).

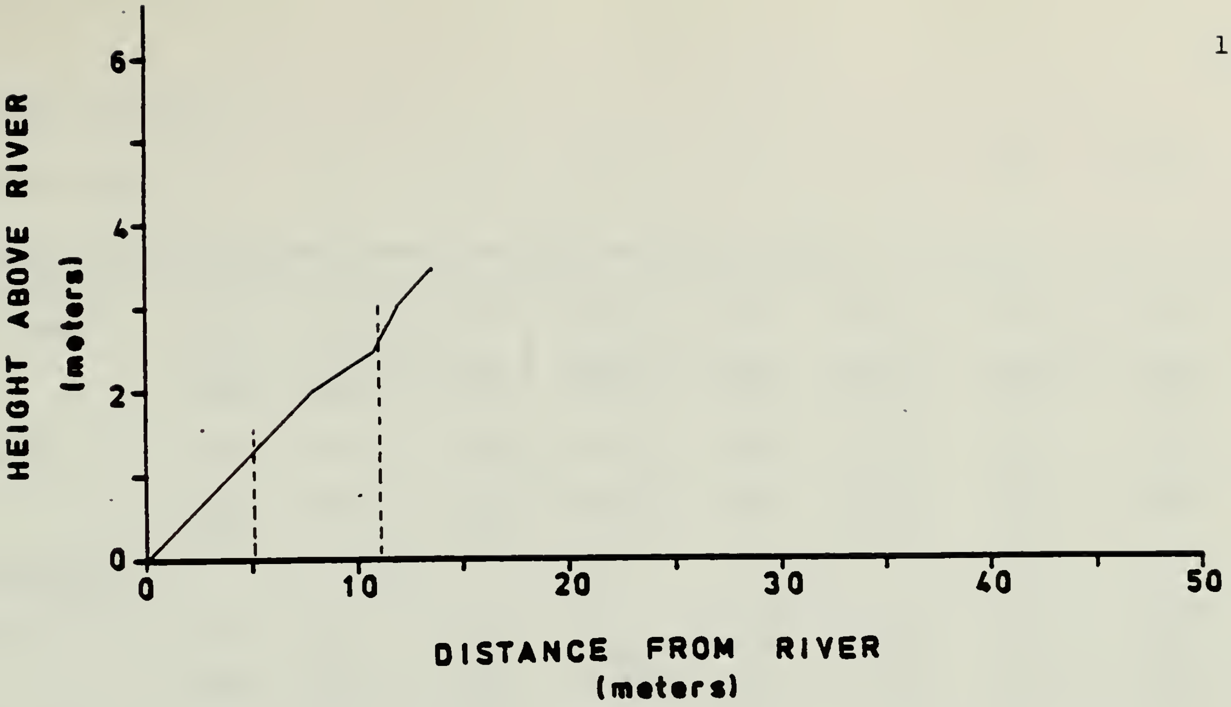


Fig. 60. Representative relief profile for Stateline sampling location. Dashed line represents the floodline.

Table 26 . Summary of substrates and vegetation coverage and density for Stateline (Green below confluence) sampling location.

Substrate: mean percent [95% confidence intervals]

Elevational zone	I	II	III	IV	V	VI	VII	VIII	IX
Fines		N O N E							
Sand	91.67	91.11	54.29	12.86	15.00	7.50	0.00	0.00	0.00
	[81.93-96.39]	[83.43-95.43]	[42.70-65.42]	[6.92-22.66]	[8.10-26.11]	[2.58-19.86]	[0.00-11.35]	[0.00-27.75]	[0.00-27.75]
Rock	8.33	6.67	24.29	0.00	15.00	7.50	20.00	0.00	0.00
	[3.61-18.07]	[3.09-13.79]	[15.75-35.49]	[0.00-5.20]	[8.10-26.11]	[2.58-19.86]	[9.51-37.30]	[0.00-27.75]	[0.00-27.75]
Litter	0.00	0.00	18.57	62.86	38.33	40.00	80.00	100.00	100.00
	[0.00-6.02]	[0.00-4.09]	[11.19-29.22]	[51.15-73.23]	[27.09-50.98]	[26.35 55.40]	[62.70-90.49]	[72.25-100.00]	[72.25-100.00]
Log	0.00	2.22	2.86	24.29	16.67	45.00	0.00	0.00	0.00
	[0.00-6.02]	[0.61-7.74]	[0.79-9.83]	[15.75-35.49]	[9.31-28.03]	[30.71-60.17]	[0.00-11.35]	[0.00-27.75]	[0.00-27.75]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

Table 26.(continued)

Vegetative cover: mean percent absolute cover [95% confidence intervals]

Elevational zones	I	II	III	IV	V	VI	VII	VIII	IX
Total cover	1.67	8.89	40.00	70.00	33.33	42.50	50.00	100.00	100.00
	[0.29-8.85]	[4.57-16.57]	[29.34-51.70]	[58.46-79.46]	[22.73-45.94]	[28.51-57.80]	[33.16-66.84]	[72.25-100.00]	[72.25-100.00]
Horsetails	0.00	2.22	12.86	41.43	0.00	2.50	0.00	0.00	0.00
	[0.00-6.02]	[0.61-7.74]	[6.92-22.66]	[30.83-53.12]	[0.00-6.02]	[0.44-12.88]	[0.00-11.35]	[0.00-27.75]	[0.00-27.75]
Sedges-Rushes		N	O	N	E				
Grass	0.00	0.00	0.00	5.71	10.00	0.00	0.00	0.00	0.00
	[0.00-6.02]	[0.00-4.09]	[0.00-5.20]	[2.24-13.79]	[4.66-20.15]	[0.00-8.76]	[0.00-11.35]	[0.00-27.75]	[0.00-27.75]
Forbs (all)	0.00	5.56	15.71	31.43	13.33	7.50	16.67	0.00	0.00
	[0.00-6.02]	[2.40-12.35]	[9.01-25.99]	[21.76-43.02]	[6.92-24.16]	[2.58-19.86]	[7.34-33.56]	[0.00-27.75]	[0.00-27.75]
G-A-A *	0.00	5.56	11.43	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-6.02]	[2.40-12.35]	[5.91-20.96]	[0.00-5.20]	[0.00-6.02]	[0.00-8.76]	[0.00-11.35]	[0.00-27.75]	[0.00-27.75]
Woody perennials (all)	1.67	1.11	20.00	7.14	6.67	35.00	40.00	100.00	100.00
	[0.30-8.85]	[0.20-6.03]	[12.31-30.81]	[3.09-15.65]	[2.62-15.92]	[22.14-50.49]	[24.59-57.68]	[72.25-100.00]	[72.25-100.00]
Tamarisk	1.67	1.11	20.00	7.14	0.00	0.00	0.00	0.00	0.00
	[0.30-8.85]	[0.20-6.03]	[12.31-30.81]	[3.09-15.65]	[0.00-6.02]	[0.00-8.76]	[0.00-11.35]	[0.00-27.75]	[0.00-27.75]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

* A sub-group of forbs: Glycyrrhiza, Apocynum, and Asclepias.

Table 26. (continued)

Vegetative density: mean number of plants per square meter [95% confidence intervals]

Elevational zone	I	II	III	IV	V	VI	VII	VIII	IX
Forbs (all)	1.83	6.11	23.71	56.86	16.50	0.00	0.00	11.00	0.00
	[1.02-3.28]	[4.70-7.95]	[20.37-23.81]	[51.54-62.72]	[13.55-20.09]	[0.00-0.96]	[0.00-1.28]	[6.14-19.70]	[0.00-3.84]
G-A-A *	1.83	6.11	4.71	1.57	1.83	0.00	0.00	0.00	0.00
	[1.02-3.28]	[4.70-7.95]	[3.36-6.62]	[0.88-2.81]	[1.02-3.28]	[0.00-0.96]	[0.00-1.28]	[0.00-3.84]	[0.00-3.84]
Woody perennials									
Tamarisk seedlings	320.00	837.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[306.01-334.63]	[818.67-856.42]	[0.00-0.55]	[0.00-0.55]	[0.00-0.64]	[0.00-0.96]	[0.00-1.28]	[0.00-3.84]	[0.00-3.84]
mature	0.00	0.00	1.43	1.57	0.00	0.00	0.00	0.00	0.00
	[0.00-0.64]	[0.00-0.43]	[0.78-2.63]	[0.88-2.81]	[0.00-0.64]	[0.00-0.96]	[0.00-1.28]	[0.00-3.84]	[0.00-3.84]
Cottonwood seedling	0.00	2.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00-0.64]	[1.61-3.70]	[0.00-0.55]	[0.00-0.55]	[0.00-0.64]	[0.00-0.96]	[0.00-1.28]	[0.00-3.84]	[0.00-3.84]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

* A sub-group of forbs: *Glycyrrhiza*, *Apocynum*, and *Asclepias*.

Table 27.

Plant Species List: Stateline Campground (Transects 32, 33, 34)

Horsetails	*Equisteum laevigatum* A. Br.
Grasses	*Agropyron smithii* Rydb.
	Elymus canadensis L.
	Oryzopsis hymenoides (R. & S.) Ricker
	Spartina pectinata Link
Forbs	*Apocynum cannabinum* var. *glaberrimum* A. DC.
	Chrysopsis villosa (Pursh) Nutt.
	Iva axillaris Pursh
	Xanthium italicum Moretti
Woody Perennials	*Acer negundo* L.
	Chrysothamnus nauseosus subsp. *graveolens* (Nutt.) H. & C.
	Juniperus utahensis (Engelm.) Lemmon
	Populus sp.
	Tamarix pentandra Pall.

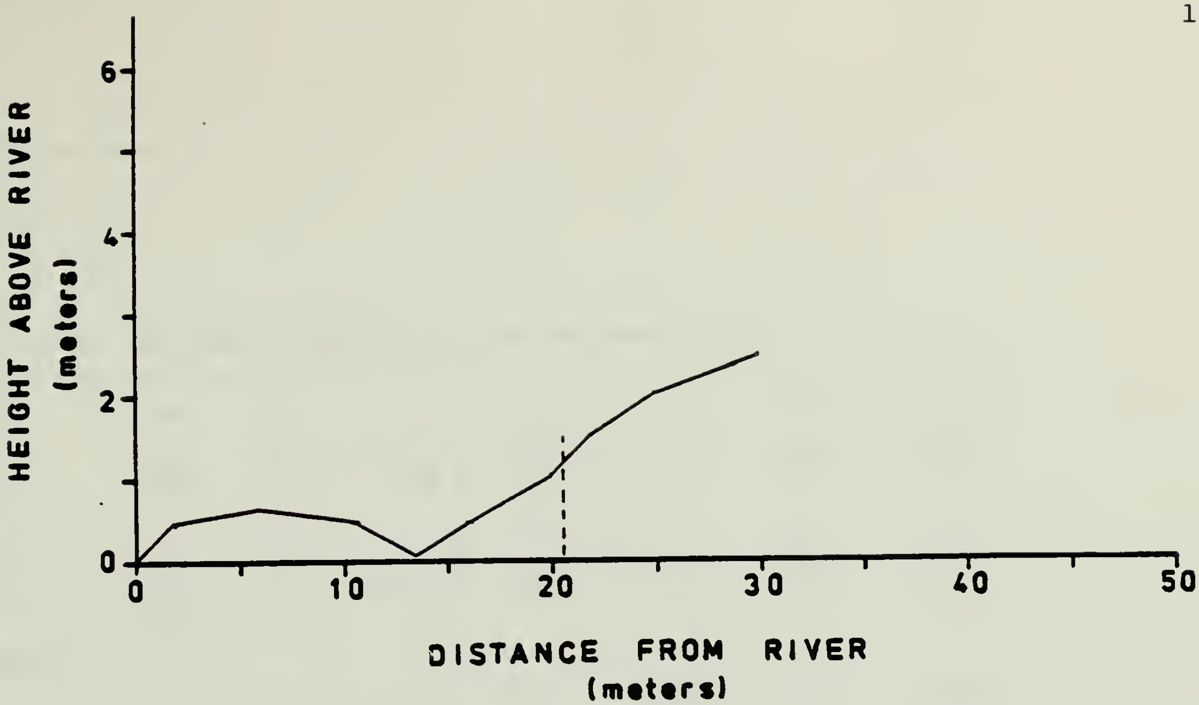


Fig. 61. Representative relief profile for Compromise sampling location. Dashed line represents the floodline.

Table 28. Summary of substrates and vegetation coverage and density for Compromise (Green below confluence) sampling location.

Elevational zone	I	II	I	II	III	IV	V
Substrate: mean percent [95% confidence intervals]							
Fines	0.00	0.00	52.50	0.00	0.00	0.00	0.00
	[0.00-4.09]	[0.00-1.26]	[44.80-60.09]	[0.00-4.09]	[0.00-4.58]	[0.00-4.09]	[0.00-2.87]
Sand	97.78	100.00	47.50	96.67	98.75	64.44	13.08
	[92.26-99.39]	[98.74-100.00]	[39.91-55.20]	[90.65-98.86]	[93.26-99.78]	[54.15-73.56]	[8.33-19.94]
Rock		N	O	N	E		
Litter	0.00	0.00	0.00	3.33	1.25	35.56	65.38
	[0.00-4.09]	[0.00-1.26]	[0.00-2.34]	[1.14-9.35]	[0.22-6.74]	[26.44-45.85]	[56.87-73.01]
Log	2.22	0.00	0.00	0.00	0.00	0.00	18.46
	[0.61-7.74]	[0.00-1.26]	[0.00-2.34]	[0.00-4.09]	[0.00-4.58]	[0.00-4.09]	[12.73-26.00]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

Table 28. (continued)

Vegetative cover: mean percent absolute cover [95% confidence intervals]

Elevational zone	I	II	I	II	III	IV	V
Total cover	0.00 [0.00-4.09]	0.33 [0.06-1.86]	1.25 [0.34-4.44]	28.89 [20.54-38.96]	61.25 [50.30-71.17]	52.22 [42.03-62.24]	69.23 [60.84-76.52]
Horsetails	0.00 [0.00-4.09]	0.00 [0.00-1.26]	0.00 [0.00 2.34]	26.67 [18.62-36.62]	47.50 [36.93-58.30]	41.11 [31.52-51.43]	51.54 [43.03-59.96]
Sedges-Rushes		N	O	N	E		
Grasses	0.00 [0.00-4.09]	0.00 [0.00-1.26]	0.00 [0.00-2.34]	0.00 [0.00-4.09]	0.00 [0.00-4.58]	0.00 [0.00-4.09]	6.92 [3.68-12.63]
Forbs (all)	0.00 [0.00-4.09]	0.00 [0.00-1.26]	0.00 [0.00-2.34]	0.00 [0.00-4.09]	12.50 [6.93-21.50]	21.11 [13.95-30.63]	14.62 [9.56-21.70]
G-A-A*	0.00 [0.00-4.09]	0.00 [0.00-1.26]	0.00 [0.00-2.34]	0.00 [0.00-4.09]	8.75 [4.30-16.98]	12.22 [6.96-20.57]	14.62 [9.56-21.70]
Woody perennials (all)	0.00 [0.00-4.09]	0.33 [0.06-1.86]	1.25 [0.34-4.44]	3.33 [1.14-9.35]	6.25 [2.70-13.81]	0.00 [0.00-4.09]	26.92 [20.04-35.13]
Tamarisk	0.00 [0.00-4.09]	0.33 [0.06-1.86]	1.25 [0.34-4.44]	3.33 [1.14-9.35]	6.25 [2.70-13.81]	0.00 [0.00-4.09]	16.15 [10.82-23.43]

Heavy vertical lines indicate significant (at 95% confidence) difference between adjacent zones.

* A sub-group of forbs: Glycyrrhiza, Apocynum, and Asclepias.

Table 28. (continued)

Vegetative density: mean number of plants per sqaure meter [95% confidence intervals]

Elevational zone	I	II	I	II	III	IV	V
Forbs	0.00	0.00	0.00	3.67	5.50	14.67	5.92
	[0.00-0.43]	[0.00-0.13]	[0.00-0.24]	[2.61-5.15]	[4.10-7.38]	[12.37-17.39]	[4.74-7.40]
G-A-A *	0.00	0.00	0.00	0.00	1.38	6.11	4.23
	[0.00-0.43]	[0.00-0.13]	[0.00-0.24]	[0.00-0.43]	[0.77-2.46]	[4.70-7.95]	[3.25-5.51]
Woody perennials							
Willow	0.00	0.00	0.06	0.66	0.49	0.00	0.00
	[0.00-0.43]	[0.00-0.13]	[0.03-0.11]	[0.52-0.84]	[0.37-0.66]	[0.00-0.43]	[0.00-0.30]
Tamarisk seedling	0.00	129.47	2.75	88.67	41.63	0.00	0.00
	[0.00-0.43]	[125.46-133.60]	[2.05-3.69]	[82.73-95.03]	[37.39-46.34]	[0.00-0.43]	[0.00-0.30]
mature	0.00	0.00	3.81	5.33	0.75	0.00	1.74
	[0.00-0.43]	[0.00-0.13]	[2.97-4.90]	[4.02-7.07]	[0.34-1.64]	[0.00-0.43]	[1.00-2.38]
Cottonwood seedling	0.00	0.73	0.00	1.22	0.00	0.00	0.00
	[0.00-0.43]	[0.48-1.11]	[0.00-0.24]	[0.68-2.19]	[0.00-0.48]	[0.00-0.43]	[0.00-0.30]
mature	0.00	0.00	0.06	0.44	0.00	0.00	0.00
	[0.00-0.43]	[0.00-0.13]	[0.01-0.35]	[0.17-1.14]	[0.00-0.48]	[0.00-0.43]	[0.00-0.30]
Shrubs	0.00	0.00	0.00	0.00	0.00	0.00	0.38
	[0.00-0.43]	[0.00-0.13]	[0.00-0.24]	[0.00-0.43]	[0.00-0.48]	[0.00-0.43]	[0.16-0.90]

Heavy vertical lines indicate significant difference (at 95% confidence) between adjacent zones.

* A sub-group of forbs: Glycyrrhiza, Apocynum, and Asclepias.

Table 29.

Plant Species List: Compromise Campground (Transects 35, 36, 37)

Horsetails	*Equisetum laevigatum* A. Br.
Sedges & Rushes	*Eleocharis macrostachya* Britt.
Grasses	*Agropyron pseudorepens* Scribn.
	Agropyron smithii Rydb.
	Elymus canadensis L.
Forbs	*Apocynum cannabinum* var. *glaberrimum* A. DC.
	Glycyrrhiza lepidota Pursh
	Iva axillaris Pursh
	Selloa glutinosa Spreng
	Xanthium italicum Moretti
Woody Perennials	*Acer negundo* L.
	Populus wislizenii (S. Wats.) Sarg.
	Salix exigua Nutt.
	Tamarix pentandra Pall.

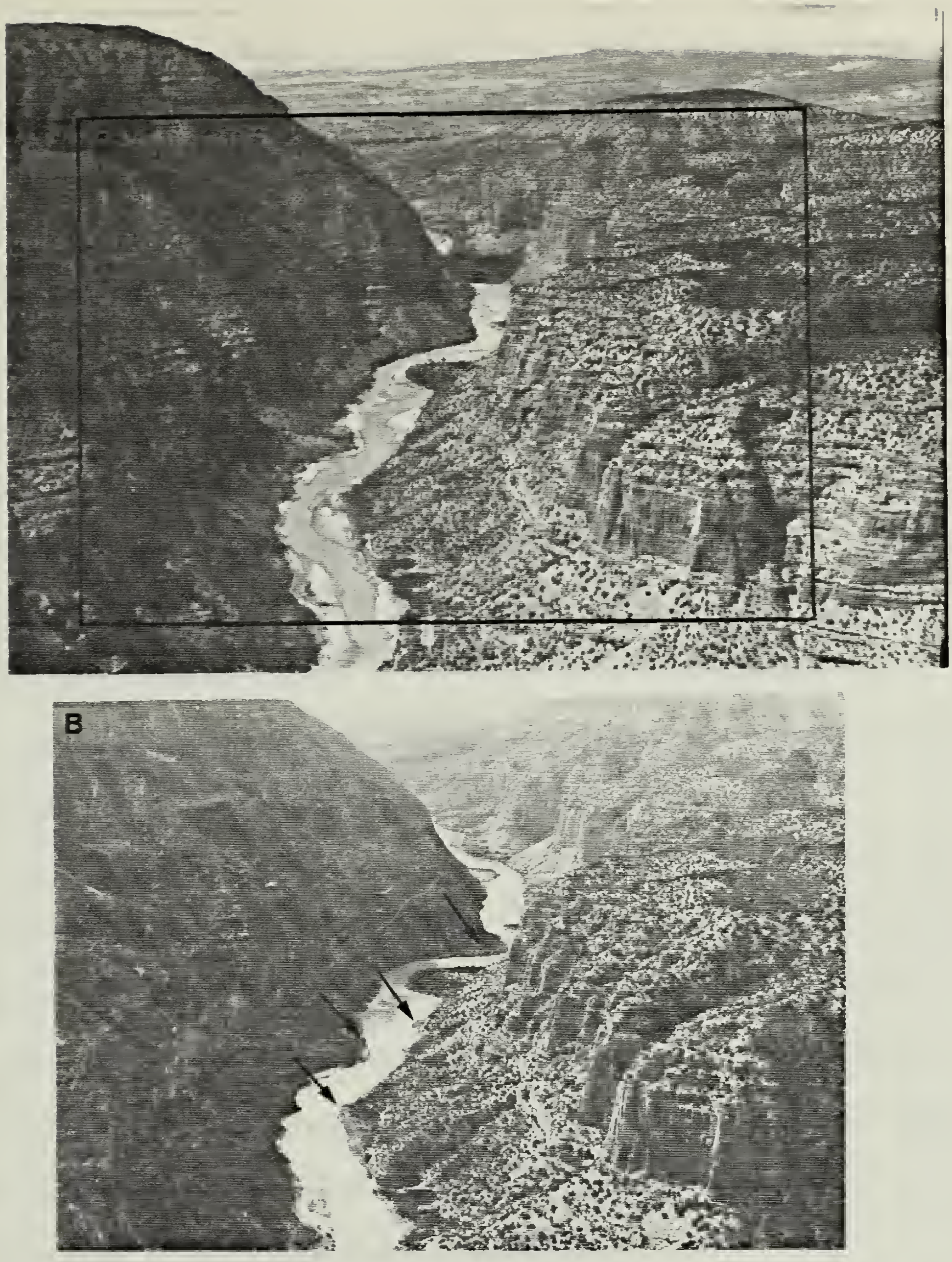


Fig. 62. Green River, Whirlpool Canyon, looking downstream.
Photo A, 10/63, unknown photographer, DNM N3015 #1477; Photo B, 9/82, Fischer. Photo A was taken during the first year of flow regulation on the Green River. Extensive bare beaches are seen below the floodline. Photo B shows the new, lower floodline, with dense vegetation established in the area in between the old and new floodlines (arrows). Tamarisk dominates these banks.

Potential Effects of Flow Regulation on the Yampa River

The goal of this research was to predict what the possible effects of controlled flow would be on the streamside vegetation of the Yampa River. The complexities of this problem are great and the current state of knowledge about the ecology of riparian communities, or even of common riparian species, is insufficient to allow more than gross predictions about the response of a particular system to specific changes. Our primary approach, therefore, has been the study of analogous river corridors and responses to change rather than direct prediction of vegetative responses. The predictions are based upon how other rivers, specifically the Green, have responded to altered flows.

It is estimated that there are over 12,000 dams over 15 m tall on a world-wide basis (Stanford and Ward 1979). Recently, a body of literature has been developing around the problem of changes in the floodplain vegetation associated with these projects. Although these data come from such diverse places as Africa, Australia, and North America, some patterns of response are beginning to emerge which provide a wider perspective to some of the observations made here.

A commonly reported outcome of regulated flow is reduced reproduction by seed of large woody perennials. This has been reported for several species, including boxelder, cottonwood, ash, and elm, on the Missouri River in North Dakota (Johnson, et al. 1976), river red-gum (*Eucalyptus camaldulensis*) in Australia (Walker 1979), and unspecified woody species in Rhodesia (Attwell 1970). On the Green River above the Yampa, boxelder was the only woody riparian species found as a seedling. Below the Yampa,

seedlings of cottonwood and tamarisk were limited to the floodzone area resulting from the variable seasonal imput of the Yampa.

Coupled with reduced seedling reproduction, a decline in riparian tree populations on the upper terraces of the floodplain has also been attributed to reduced flows. Acacia xanthophloea and Ficus sycamorus populations are reported to be declining below the Pongolapoort Dam in South Africa (Davies 1979). Increment cores from four tree species along the Missouri River reveal reduced growth rates after completion of the Garrison Dam upstream (Reily and Johnson 1982). On the Green River, however, this type of response was not apparent.

Change in cover and species composition along the shores of regulated streams is commonly reported. Perennials grasses commonly dominate the new shoreline vegetation (Attwell 1970; Davies 1970). Submergent plants quickly invade where scouring has ceased and water clarity increased due to flow regulation (Davies 1970). A study of the vegetational changes below Ahosombo Dam on the Volta River revealed decreased populations of three species, the disappearance of seven species and the invasion of the shoreline by three swamp species (Ibid.).

On the Colorado River below Glen Canyon Dam, Turner and Karpiscak (1980) found tamarisk to be the principal invader of the post-dam shoreline vegetation. Wetland species, such as Phragmites communis and Typha spp. were also noted to have increased significantly along the river margins. Grass invasion seems to have been less important here than on the Green; this difference may be attributable to hotter and drier conditions on the Colorado. Cooler, wetter climate in northern Colorado and Utah may also be responsible for the increase in willow and cottonwood on the Green

River, in contrast to the general decline of similar species reported elsewhere.

The Green River appears to have undergone an initial invasion of tamarisk into the floodzone in the first several years of regulation, but the stands do not show evidence of continuing expansion. On the contrary, in the Canyon of Lodore, most of the plants are small and decadent, despite being nearly 20 years old. Just above the confluence with the Yampa (where the river gradient flattens out considerably), and in flatter portions of the Green below the confluence, the plants are more vigorous.

The growth of wetland species along the shoreline of the Green is marked. As reported for the Colorado River, Phragmites is commonly seen along the river margin in the Canyon of Lodore. Cattails (Typha) were also observed, but only very locally. Grasses, sedges, and rushes are the primary invaders of the shoreline. Equisetum and Glycyrrhiza appear to continue growth in the areas where they had been established prior to flow regulation, although it is difficult to evaluate their relative vigor and extent compared to pre-dam stands, or compared to distribution of these species under differing substrate and flow conditions on the Yampa.

Thus it can be concluded that the general responses of the Green River to regulated flow regime bear important similarities to that of other river systems of the world, but also that the local physical environment can play a role in determining exactly how various components of the vegetation respond. Consideration of the differences between the physical environments of the Green and Yampa rivers must be made when using the Green as an analogue to the Yampa. The Lodore and Whirlpool Canyons differ

in geology, orientation, width, depth, sinuosity, and gradient from the Yampa Canyon and from each other. These factors can affect the temperature extremes, the size and nature of sediment deposits, humidity, light regime, river velocity, and geochemistry of the canyon environment, all of which may in turn affect the vegetational response to altered flow regime.

Potential vegetation changes on the Yampa corridor are further dependent on the degree and source of flow alteration. Controlled releases from only the upper part of Yampa (above the Little Snake) could result in a very different vegetative response than control of the Little Snake only, or control of both. For this reason, predictions must first be made in relation to the components of regulated flow which are most likely to affect stream-side vegetation.

Perhaps the most obvious and likely of these components is a reduced mean maximum discharge. The effect of this is illustrated in Lodore Canyon where there is clear evidence of a downward movement of riparian and upland species (specifically boxelder, juniper, rabbitbrush, and Chrysopsis) into the pre-dam floodzone. A similar response can be predicted for the Yampa, although the primary species involved would probably include Rhus, Artemisia, and Ephedra as well as those listed above. Also due to reduced maximal flows, the upper sections of the bare sand beaches, at Anderson Hole, Laddie Park, and Box Elder Campground, will be opened to wind erosion, at least until they can be stabilized by vegetation. Some small dune areas have developed from the exposed and unflooded previous floodzone of the Green River.

Coupled with a reduced maximal discharge, a common feature of

regulated flows is an increased mean minimum discharge. The resultant increased minimum river stage will likely kill the plants presently established along the low water line of the Yampa, although these would probably be easily replaced higher on the floodzone. More importantly, the floodzone will be reduced to a very narrow band. The floodzone on the Yampa was measured to be over 30 m wide on some gradually sloping banks. On the Green, the zone of normal water fluctuation was seldom more than 5 m wide.

A significant aspect of natural flow regimes, and one which can not be adequately studied in a single year of data collection, is that of especially high or low water years ("unusual" in the short term, but characteristic of the long term range of flow variability). Spring floods which greatly exceed the mean maximum discharge are probably vital in maintaining the floodzone vegetation of the Yampa River in its present state. These floods can create or destroy floodzone and riparian habitats, and scour away established stands of plants which normal flood level would not have the power to do. Heavy floods can have an important role in the long-range reproductive history of certain species, by redistributing vegetative propagules (such as rhizomes) in new areas of the river, or depositing seeds above the normal floodline, where seedlings of such species as cottonwood can grow free of the effects of scouring until the next high water year (Irvine and West 1979). Conversely, unusually low discharges during the spring period can allow for the establishment of plants farther below the floodline than they would otherwise occur.

The loss of these aberrant spring discharges through flow regulation could greatly curtail the successful reproduction of cottonwood along the

Yampa corridor. The sparsity of cottonwoods of ages between very young and very old indicates that the conditions necessary for successful reproduction of this species on the Yampa River occur very infrequently. Flow regulation may effectively eliminate them.

Lack of very high water years will also allow the uncontrolled growth of clone-forming species, such as Carex, Phragmites, Equisetum, Glycyrrhiza, and Apocynum. All of these species occur on the Yampa, usually in discrete patches. The historic photos show these patches to be dynamic over long periods, indicating probable periodic removal by large floods. The lack of low water years would probably not have as pronounced an effect on vegetation, but could reduce the reproductive success of willow, tamarisk, and cottonwood along the river.

The regulated flow discharged from a hydroelectric dam will exhibit a high daily fluctuation as a result of peak energy demands in urban centers. The rapid drops in river stage associated with these fluctuations have been noted by Attwell (1970) to produce increased bank erosion due to release of bank storage water. This would be most prominent on sand deposits which are highly erodable and common along the Yampa.

These rapid fluctuations also are important in maintaining a moist or saturated soil in the floodzone, but they do not scour. The result is the invasion of wetland species into the adjacent section of the floodzone. Plants which presently occur on the Yampa River which would be favored in such an environment include Carex, Eleocharis, Juncus, Phragmites, Distichlis, Agropyron, and Polygonum. Species which would likely invade this zone but were not found along the Yampa during the study period might include Agrostis alba, Ranunculus cymbalaria, Potentilla sp., and Typha sp.

The effects of the reduced sediment load in the discharge from an impoundment are similar to those described above. Sediment-free water has a greater capacity to pick up and hold sediments from the channel bed than sediment-loaded water (Leopold, et al. 1964). The discharge from a dam would, therefore, tend to erode sand banks as it has below Glen Canyon Dam (Dolan et al. 1974). The cleaner water will also allow greater light penetration and be less abrasive, thus favoring the growth of submergent species, such as streamers of green algae (Potter and Pattison 1976). Polygonum amphibium may significantly increase its extent on the river under such conditions, and invasion of other submergent species is likely.

From the above discussion and the vegetational profiles of the seven sites selected for analysis on the Yampa River, predictions might be made as to the short term responses of each site to a suite of natural flow regime alterations typical of upstream hydroelectric development. These might include a lower maximum flow, higher minimum flow, little year-to-year variation in release, daily peak and recharge/discharge fluctuation, and reduced sediment load. These predictions assume initial vegetative conditions are as they were in August, 1982, and that the impact by wildlife and human activity is minimal.

The beach as Anderson Hole is wide at low water and relatively free of stabilizing vegetation. Erosion by water and wind could be high, inhibiting establishment of vegetation on the exposed sand. Cottonwood seedlings were common here and this species could recruit more plants into the population during the first year of controlled flow, but subsequent reproduction would not be favored. Unstable sand could dominate this site for many years after initiation of controlled flow.

The willows on the gravel island at Tepee Rapids might persist for several years of controlled flow, but as seen on the Green, they would eventually give way to a more xeric vegetation in the center of the island. Grasses, sedges, and rushes would probably form a fringe around the island along with the surviving willows.

The heavily vegetated beach at Haystack Rock would be more stable than that at Anderson Hole. Tamarisk, willow, Glycyrrhiza, and Equisetum, which already exist in the floodzone would benefit from the high soil moisture and lack of scouring provided by a regulated river, although reproduction of the first two species would not be favored. The potential for a dense growth of Glycyrrhiza and Equisetum developing at this site is high.

The beach above Big Joe Rapids also has a high potential for the development of dense stands of certain species. The tamarisk population would increase dramatically in the exposed area, at least in the first year. Cottonwood also has the potential for establishment here. It is not known how the stands of Polygonum amphibium would respond to controlled flow, but the quiet waters of the site coupled with small, rapid fluctuations of river level would be highly favorable to emergent species of this type.

Hypothetical changes at the three sites below Big Joe would include a pulse of new tamarisk plants in the newly exposed sections of the floodzone, and an increase in grasses, sedges, and rushes along the shoreline. Other adjustments could include a downward movement of riparian and upland species, such as boxelder, Artemisia, and Chrysothamnus, and possibly, at Mather's Hole, Box Elder, and similar sites, a decline in the boxelder dominated riparian community of the upper terraces due to lowered water levels.

Two final comments must be made. First, the above predictions assume only a single set of alterations in the flow regime which are not quantified. If, for example, only the Yampa flow above the Little Snake is altered and the Little Snake is able to add a small amount of seasonal variability to the flow and much of the present silt load, the resultant vegetational changes could be much different, as seen, for example, between the sampling sites in Lodore Canyon and Whirlpool Canyon. The number of possible variations on flow regime is almost infinite. The one chosen here for exemplification most closely resembles the flow of the Green above the confluence, the river for which we have the best documentation of change.

Second, these predictions are only short-term, possibly only useful in the first one or two decades after initiation of flow control. Our data do not allow for long-term predictions which may involve complete species replacements in the various vegetation zones and changes in the geomorphology of the river induced by stream-side vegetation.

SUMMARY

Analysis of the vegetation at selected sites along the Yampa River corridor in Dinosaur National Monument revealed a zone of vegetation between the high and low water lines which was distinct from vegetation types higher on the slopes in total cover, species composition, and dominant growth forms. The vegetation of this zone is shaped by the unregulated flows of the Yampa and Little Snake river, which can be characterized by high discharge during the late spring followed by low discharge in the late-summer, fall and winter months, small daily fluctuation in discharge, years of extreme high and low flows, and a high sediment load.

A map of the Yampa River corridor within the Monument was prepared illustrating the major upland and riparian vegetation communities as well as the areas of species dominance along the floodzone. Plant collections were made along all river corridors in the Monument (see Appendix). Data collected documented vegetation coverage and density changes with respect to elevation above the summer river level, surficial substrate coverage along the same elevational gradient, tamarisk ages from both rivers determined by annual ring counts, soil texture association with successful tamarisk seedling establishment, and comparative photographs from high and low water periods during 1982 as well as historical photographs spanning 112 years.

Using data gathered from the Green River, as well as literature on vegetational changes along other regulated rivers, predictions were made concerning the potential response of the vegetation within the Yampa

River floodzone to a hypothetical regulated flow regime. These were:

1. an invasion of species from higher vegetation zones into lower zones.
2. reduced vigor or eventual elimination of species typically-occurring along the upper margins of the present riparian zone.
3. an initial increase in the number of tamarisk, willow, and cottonwood plants followed by virtual elimination of successful reproduction by seed of these species.
4. erosion of sand deposits presently devoid of stabilizing vegetation.
5. expansion of presently existing stands of rhizomatous species, such as *Carex aquatilis*, *Glycyrrhiza lepidota*, *Apocynum cannabinum*, *Equisetum* sp., and *Phragmites communis*.
6. development of a new vegetation type along the margins of the river dominated by wetland species of grasses, sedges, rushes, and forbs.
7. long-term changes in channel morphology resulting from bank stabilization and sediment accumulation by the shoreline vegetation.
8. continued, unpredictable changes in these communities as a result of ecological succession toward a stable equilibrium.

In addition to the biotic nature of these changes, the visual impact of the river corridor will also be considerably altered. There is further the threat of significant tamarisk invasion, which could reduce the quality and number of available campsites already in short supply. The high reproductive and adaptive potential of tamarisk on sand deposits

(particularly those with substantial components of finer sediments) of the lower 26 miles of the Yampa opens the possibility for the establishment of impenetrable thickets of this exotic species in some locations.

LITERATURE CITED

Attwell, R.I.G. 1970. Some effects of Lake Kariba on the ecology of a floodplain of the Zambezi Valley of Rhodesia. Biol. Conserv. 2(3):189-196.

Cooper, C.F. 1963. Tamarisk as a potential noxious shrub. Austr. Inst. of Agr. Sci. 29(3):178-181.

Costello, D.F. 1954. Vegetation zones in Colorado. p. iii-x In H.D. Harrington, Manual of the plants of Colorado. Swallow Press, Chicago.

Davies, B.R. 1979. Stream regulation in Africa: a review. p. 113-142 In J.V. Ward and J.A. Stanford (eds.), The ecology of regulated streams. Plenum Press, New York.

Dolan, R., A. Howard, and A. Gallenson. 1974. Man's impact on the Colorado River in the Grand Canyon. Amer. Sci. 62:392-401.

Flowers, Seville. 1963. Study of the non-vascular plants of Dinosaur National Monument. In Studies of biota in Dinosaur National Monument, Utah and Colorado. Inst. of Envir. Biol. Res., Univ. of Utah, Div. of Biol. Sci., Misc. Papers 1.

Gary, H.L. 1963. Root distribution of five-stamen tamarisk, seepwillow, and arrowweed. Forest Sci. 9(3): 311-314.

Graf, W. L. 1978. Fluvial adjustments to the spread of tamarisk in the Colorado Plateau region. Geol. Soc. of Amer. Bull. 89:1491-1501.

Hansen, W.R. 1977a. Geologic map of the Jones Hole quadrangle, Uinta Co., Utah, and Moffat Co., Colorado. U.S. Geol. Surv., GQ-1401.

Hansen, W.R. 1977b. Geologic map of the Canyon of Lodore, South Quadrangle, Moffat Co., Colorado. U.S. Geol. Surv., GQ-1403.

Hansen, W.R. 1978. Geologic map of the Zenobia Peak quadrangle, Moffat Co., Colorado. U.S. Geol. Surv., GQ-1408.

Hansen, W.R., and P.E. Carrara. 1979. Geologic map of the Tanks Peak quadrangle, Moffat Co., Colorado. U.S. Geol. Surv., GQ-1534.

Hansen, W.R., P.E. Carrara, and P.D. Rowley. 1979. Geologic map of the Haystack Rock, Moffat Co., Colorado. U.S. Geol. Surv., GQ-1535.

Harrington, H.D. 1964. Manual of the plants of Colorado. 2nd ed. Swallow Press, Chicago.

Holmgren, A.H. 1962. The vascular plants of the Dinosaur National Monument. National Park Service, Dinosaur National Monument, Colorado.

Holmgren, A.H., and J.L. Reveal. 1966. Checklist of the vascular plants of the Inter-mountain Region. p. 77-161 In A. Cronquist, A.H. Holmgren, N.H. Holmgren, and J.L. Reveal, Inter-mountain flora, Vol. I. Hafner, New York.

Horton, J.S., F.C. Mounts, and J.M. Krafts. 1960. Seed germination and seedling establishment of phreatophyte species. U.S. Dept. of Agr., Rocky Mt. Forest and Range Expt. Stn. Paper 48.

Irvine, J.R., and N.E. West. 1979. Riparian tree species distribution and succession along the lower Escalante River, Utah. Southwest Nat. 24(2): 331-346.

Johnson, W.C., R.L. Burgess, and W.R. Keammerer. 1976. Forest overstory vegetation and environment on the Missouri River floodplain in North Dakota. Ecol. Mongr. 46:59-84.

Leopold, L.B., M.G. Wolman, and J.P. Miller. 1964. Fluvial processes and geomorphology. Freeman, San Francisco.

Pollard, J.H. 1977. A handbook of numerical and statistical techniques, with examples mainly from the life sciences. Cambridge University Press, Cambridge, England.

Potter, L.D., and N.B. Pattison. 1976. Shoreline ecology of Lake Powell. Lake Powell Research Project Bull. 29. Instit. of Geophysics and Planetary Physics, U.C.L.A., Los Angeles.

Reily, P.W., and W.C. Johnson. 1982. The effects of altered hydrologic regime on tree growth along the Missouri River in North Dakota. Can. J. Bot. 60:2410-2423.

Rowley, P.D., J.R. Dyni, W.R. Hansen, and G.N. Pipiringos. 1979. Geologic map of the Indian Water Canyon quadrangle, Moffat Co., Colorado. U.S. Geol. Surv., GQ-1516.

Shoemaker, E.M., and H.G. Stephens. 1969. The Green and Colorado River canyons observed from the footsteps of Beaman and Hillers 97 years after Powell. Geol. Soc. of Amer. Abstracts with Programs for 1969, Part 5.

Shoemaker, E.M., and H.G. Stephens. 1975. First photographs of the canyonlands. p. 111-222 In J.E. Fassett (ed.), Canyonlands country. Four Corners Geological Society Guidebook, 8th Field Conference.

Simons, D.B. 1979. Effects of stream regulation on channel morphology. p. 95-112 In J.V. Ward and J.A. Stanford (eds.), The ecology of regulated streams. Plenum Press, New York.

Stanford, J.A., and J.V. Ward. 1979. Stream regulation in North America. p. 215-236 In J.V. Ward and J.A. Stanford (eds.), The ecology of regulated streams. Plenum Press, New York.

Sumison, C.T. no date. Water resources of Dinosaur National Monument, Colorado and Utah. U.S. Geol. Surv., Open file report 76-580, Salt Lake City.

Tomanek, G.W., and R.L. Ziegler. 1961. Ecological studies of saltcedar. Offsett printing, Fort Hays Kansas State College, Hays, Kansas.

Turner, R.M., and M.M. Karpsicak. 1980. Recent vegetative changes along the Colorado River between Glen Canyon Dam and Lake Mead, Arizona. U.S. Geol. Surv. Prof. Paper 1132.

U.S. Geological Survey. 1961-present. Water resources data for Colorado. Part 1, surface water records. U.S. Geol. Surv., Denver.

U.S. Geological Survey. 1964-present. Water resources data for Utah. Part 1, surface water records. U.S. Geol. Surv., Salt Lake City.

Walker, K.F. 1979. Regulated streams in Australia: the Murray-Darling river system. p. 143-164 In J.V. Ward and J.A. Stanford (eds.), The ecology of regulated streams. Plenum Press, New York.

Warren, D.K., and R.M. Turner. 1975. Saltcedar (Tamarix chinensis) seed production, seedling establishment, and response to inundation. Az. Acad. of Sci. J. 10:135-144.

Welsh, S.L. 1957. An ecological survey of the vegetation of the Dinosaur National Monument, Utah. Master's Thesis, Department of Biology, Brigham Young University, Provo.

Whitlow, T.H., and R.W. Harris. 1979. Flood tolerance in plants: a state-of-the-art review. Environmental and Water Quality Operational Studies, Tech. Rep. E-79-2. U.S. Army Engineer Waterways Expt. Stn., Vicksburg, MS.

APPENDIX

Plant species of the Yampa and Green Rivers, Dinosaur National Monument, April-September, 1982[1]

ACERACEAE

*Acer negundo L.	boxelder	Yampa and Green rivers

AMARANTHACEAE

Amaranthus palmeri Wats.	careless weed pigweed	Yampa River, Mather Hole

ANACARDIACEAE

*Rhus trilobata Nutt. ex. T.&G.	squawberry	Yampa and Green rivers

APOCYNACEAE

Amsonia jonesii Woodson	amsonia	Green River, Tree Island
Apocynum cannabinum var. glaberrinum A. DC.	hemp dogbane	Yampa River, Tepee Camp Green River, Kolb Camp Common along Yampa River

BERBERIDACEAE

Berberis repens Lindl.	Oregon grape	Yampa River, across from Mather Hole

CAPPARIDACEAE

Cleome lutea Hook	beeplant	Yampa River, Laddie Park
Cleome serrulata Pursh	doveweed, beeweed	Yampa River, Laddie Park

CAPRIFOLIACEAE

Sambucus coerulea Raf.	blueberry elder	Yampa River, Harding Hole Green River, Wade and Curtis Camp

CARYOPHYLLACEAE

Spergularia sp.	spergularia	Yampa River, Big Joe Camp

CHENOPODIACEAE

Atriplex argentea Nutt.	atriplex	Green River, Echo Park
Chenopodium leptophyllum Nutt.	slimleaf goosefoot	Yampa River, Mather Hole
cf. Chenopodium fremontii Wats.	goosefoot	Yampa River, Mather Hole
cf. Chenopodium glaucum L.	goosefoot	Yampa River, Laddie Park
Eurotia lanata (Pursh) Moq.	winterfat	Green River, Island Park
**Halogeton glomeratus (Bieb.) Mey	halogeton	Green River, Echo Park

CHENOPODIACEAE (continued)

***Salsola kali L.	tumbleweed	Yampa River

COMPOSITAE

Achillea lanulosa Nutt.	western yarrow	Yampa River, Bower Draw
Antennaria rosulata Rydb.	pussytoes	Yampa River, Bower Draw
**Arctium minus (Hill)	burdock	Green River, Jones Hole, Island Park
Artemisia ludoviciana Nutt.	Louisiana wormwood	Green River, Kolb Camp, Wade and Curtis Camp Yampa River
*Artemisia tridentata Nutt.	big sagebrush	Yampa and Green rivers
Aster hesperinus Gray var. hesperinus	aster	Yampa River, Mather Hole Green River, Kolb Camp, Rippling Brook
Brickellia scabra (Gray)A.Nels	bricklebush, flythicket	Green River, Rippling Brook
Chaenactis douglasii (Hook.) Hook. & Arn.	Douglas falseyarrow	Yampa River, Bower Draw
Chrysopsis villosa (Pursh) Nutt. ex DC.	hairy goldaster	Yampa River, Anderson Camp Common along Yampa and Green rivers
Chrysothamnus nauseosus subsp. bigelovi	rubber rabbitbrush	Green River, Rippling Brook
Chrysothamnus nauseosus complex	rubber rabbitbrush	Yampa River, Mather Hole
Chrysothamnus nauseosus subsp. graveolens (Nutt.) H.&C.	rubber rabbitbrush	Green River, Limestone Camp, Stateline Camp
Chrysothamnus viscidiflorus subsp. linifolius (Greene)H.&C.	Douglas rabbitbrush	Yampa River, Laddie Park, Green River, Rippling Brook
Cirsium bipinnatum (Eastw.) Rydb.	thistle	Green River, Wade and Curtis Camp
Cirsium sp.	thistle	Green River, Kolb Camp
Franseria discolor Nutt.	bur-sage	Common along Yampa River Anderson Hole
Gaillardia aristata Pursh	blanket flower	Yampa River, Bower Draw
Gnaphalium palustre Nutt.	cudweed	Yampa River, Big Joe Camp Green River, Kolb Camp
Grindelia squarrosa (Pursh) Dunal var. squarrosa	curlycup gumweed	Yampa River, Mather Hole common in Monument
Hymenopappus filifolius var. cinereus (Rydb.)I.M.Johnst.	white rag-weed	Yampa River, Bower Draw
Iva axillaris Pursh	poverty sumpweed	Yampa River, Anderson Hole
Selloa glutinosa Spreng	selloa	Yampa River, Mather Hole Green River, gravel island above Rippling Brook, Limestone Camp, Kolb Camp
Lygodesmia grandiflora (Nutt.)T.&G.	skeleton plant	Green River, Island Park
Senecio multilobatus Torr. & Gray	lobeleaf groundsel	Yampa River, Bower Draw
cf. Sonchus asper (L.) Hill	sonchus	Yampa River, Mather Hole

COMPOSITAE (continued)

Townsendia incana Nutt.	beenuts	Yampa River, Johnson Canyon
Xanthium italicum Moretti	cocklebur	Yampa River
Xanthium strumarium L. var. *canadense* (Mill.) Torr.	cocklebur	Yampa River, Mather Hole

CORYLACEAE

Betula occidentalis Hook	water birch	Yampa River, Harding Hole

CRUCIFERAE

Arabis selbyi Rydb.	rockcress	Green River, Pot Creek
Draba reptans (Lam.)Fernald	whitlowort	Green River, Kolb Camp
Lepidium medium var. *pubescens* (Greene) Robins	pepperweed	Yampa River, Laddie Park
Rorripa nasturtium-aquaticum (L.) Schinz & Thell.	watercress	Green River, Limestone Camp

CUPRESSACEAE

Juniperus utahensis (Engelm.) Lemmon	Utah juniper	Yampa River, Laddie Park Common along Green and Yampa rivers

CYPERACEAE

Carex aquatilis Wahlenb.	sedge	Yampa River, Jones Hole
Carex lanuginosa Michx.	sedge	Green River, Kolb Camp
Eleocharis macrostachya Britt.	spikerush	Green River, Harp Falls, Limestone Camp
Scirpus americanus Pers.	bulrush	Green River, Kolb Camp, Harp Falls

EQUISETACEAE

Equisetum arvense L.	horsetail	Yampa River, Big Joe Camp Green River, Kolb Camp
Equisetum laevigatum A. Br.	horsetail	Yampa River, Tepee Camp, Haystack Camp, Mather Hole Green River, Kolb Camp, Harp Falls, State Line Camp

EUPHORBIACEAE

Euphorbia glyptosperma Engelm.	ridgeseed spurge	Yampa River, Laddie Park
Euphorbia sp.	spurge	Yampa River, Anderson Hole

GRAMINEAE

Agropyron pseudorepens Scribn.	false quackgrass	Green River, Kolb Camp, Compromise Camp
Agropyron repens (L.)Beauv.	quackgrass	Yampa River, Anderson Hole Green River, Harp Falls
Agropyron trachycaulum (Link)Malte	slender wheatgrass	Yampa River, Tepee Camp Laddie Park Green River, Rippling Brook, Limestone Camp

GRAMINEAE (continued)

Agropyron smithii Rydb.	western wheatgrass	Yampa River, Tepee Camp
Agropyron sp.	wheatgrass	Green River, Kolb Camp
Agrostis alba L.	redtop bentgrass	Green River, Kolb Camp, Harp Falls, Limestone Camp
Bromus inermis Leyess	smooth brome	Green River, Rippling Brook
cf. Bromus sp.	brome-chess	Green River, Kolb Camp
Calmagrostis scopulorum Jones	Jones reedgrass	Green River, Kolb Camp, Rippling Brook
Deschampsia caespitosa (L.) Beav.	tufted hairgrass	Green River, Harp Falls, Limestone Camp
*Distichlis stricta (Torr.) Rydb.	saltgrass	Yampa and Green rivers
Echinochloa crusgalli (L.) Beauv.	barnyard grass	Green River, Harp Falls
Elymus canadensis L.	Canada wildrye	Green River, Rippling Brook
Elymus sp.	wildrye	Green River, Harp Falls
Muhlenbergia asperifolia (Nees & Mey) Parodi	alkali muhly	Green River, Kolb Camp
Muhlenbergia racemosa (Michx.) B.S.P.	green muhly	Green River, Rippling Brook
cf. Muhlenbergia racemosa (Michx.) B.S.P.	green muhly	Green River, Rippling Brook
Oryzopsis hymenoides (R.&S.) Ricker	Indian ricegrass	Yampa and Green Rivers
Panicum sp.	witchgrass	Yampa River, Mather Hole
*Phragmites communis Trin.	common reed	Yampa and Green Rivers
Poa interior Rydb.	inland bluegrass	Green River
Poa pratensis L.	Kentucky bluegrass	Yampa River, Mather Hole
*Polypogon monspeliensis (L.) Desf.	rabbitfoot polypogon	Yampa River
Spartina gracilis Trin.	alkali cordgrass	Green River, Kolb Camp
Spartina pectinata Link	prarie cordgrass	Yampa River, Mather Hole
Spartina sp.	cordgrass	Yampa River, Mather Hole
*Sporobolus cryptandrus (Torr.) A. Gray	sand dropseed	Yampa River
Stipa comata Trin. & Rupr. var. comata	needle and threadgrass	Yampa River, Mather Hole

JUNCACEAE

Juncus balticus Willd. var. montanus Engelm.	wire rush	Green River, Kolb Camp
Juncus bufonius L.	toad rush	Yampa River, Mather Hole
Juncus filiformis L.	rush	Green River, Harp Falls
Juncus longistylis Torr.	rush	Green River, Kolb Camp
Juncus sp.	rush	Yampa River, Big Joe Camp

LABIATAE

Mentha arvensis L.	mint	Yampa River, Mather Hole Green River, Kolb Camp

LEGUMINOSEAE

Astragalus ceramicus Sheld. var. ceramicus	milkvetch	Green River, Island Park
Astragalus mollissimus var. thompsonae	milkvetch	Yampa River, Harding Hole
Glycyrrhiza lepidota (Nutt.)Pursh	licorice	Yampa River, mi. 29.9, common along river
Lupinus argenteus Pursh	silvery lupine	Green River, Island Park
**Medicago sativa L.	alfalfa	Yampa River, Mather Hole
**Medicago lupilina L.	black medic	Yampa River, Mather Hole
Melilotus officianalis (L.) Lam.	yellow sweetclover	Green River, Limestone Camp
Psoralea lanceolata Pursh	beaverbred scurfpea	Yampa River, Harding Hole

LILIACEAE

Calochortus sp.	mariposa lily	Green River, Island Park

MALVACEAE

Sphaeralcea fendleri Gray	fendler globemallow	Green River, Island Park

NYCTAGINACEAE

Oxybaphus diffusus (Heller)	desert four o'clock	Yampa River, Mather Hole
Oxybaphus lanceolatus (Rydb.)Standl.	desert four o'clock	Yampa River, Mather Hole

ONAGRACEAE

*Oenothera sp.	evening primrose	Yampa and Green rivers

PLANTAGINACEAE

Plantago major L.	rippleseed plantain	Yampa River, Mather Hole

POLEMONIACEAE

Gilia calcarea M.E. Jones	gilia	Yampa River, Bower Draw
Ipomopsis aggregata (Pursh) V. Grant subsp. aggregata	skyrocket gilia	Yampa River, Bower Draw
Phlox austromontana Coville	desert phlox	Yampa River, Bower Draw
Phlox hoodii Rich.	hood phlox	Yampa River, Harding Hole Wagon Wheel Point

POLYGONACEAE

*Eriogonum sp.	wild buckwheat	Yampa and green rivers
Polygonum amphibium L.	knotweed	Yampa River, Big Joe Camp
Polygonum lapathifolium L.	knotweed	Yampa River, Mather Hole Green River, Harp Falls
Polygonum sp.	knotweed	Green River, Kolb Camp, Limestone Camp
Rumex fueginus Phil.	dock	Yampa River, Laddie Park
Rumex triangulivalvis (Danser) Rech.	dock	Yampa River, Deer Lodge Park

POLYGONACEAE (continued)

Rumex sp.	dock	Yampa River, Mather Hole Green River, Kolb Camp

RANUNCULACEAE

Aquilegia micrantha Eastw.	columbine	Yampa River, Toad Hall
Clematis ligusticifolia Nutt.	virginsbower	Yampa River, mi. 43.5 Green River, Rippling Brook common along Yampa River
Ranunculus cymbalaria Pursh var. *saximontanus* Fern.	desert crowfoot	Yampa River, Harding Hole Green River, Kolb and Limestone camps
Amalanchier utahensis Koehne.	Utah service berry	Yampa River, Harding Hole
Holodiscus dumosus (Nutt.) Heller	ocean spray	Yampa River, mi. 43.5
Potentilla anserina L. var. *anserina*	silverweed cinquefoil	Yampa River, Anderson Hole Green River, Kolb Camp
Prunus virginiana L.	chokecherry	Yampa River, Thanksgiving Gorge
**Rosa* sp.	rose	Yampa River

RUBIACEAE

Galium coloradoense W.F. Wright	bedstraw	Yampa River, Bower Draw

SANTALACEAE

Comandra umbellata (L.) Watt.	Bastard flax	Yampa River, Anderson Hole
**Populus wislezenii* (S.Wats.)Sarg.	cottonwood	Yampa and Green rivers
Salix exigua Nutt.	coyote willow	Yampa River, Tepee Camp, Haystack Camp, Mather Hole Green River, Rippling Brook
cf. *Salix exigua* Nutt.	coyote willow	Yampa River, Laddie Park

SAXIFRAGACEAE

Fendlera rupicola A. Gray	cliff fendlerbush	Yampa River, mi. 43.5
Heuchera parvifolia Nutt. ex T. & G.	alumroot	Yampa River, Thanksgiving Gorge

SCROPHULARIACEAE

Castilleja chromosa A. Nels.	Indian paintbrush	Yampa River, Deer Lodge Park
**Verbascum thapsus* L.	flannel mullein	Yampa River
cf. *Veronica*	speedwell	Green River, Kolb Camp

TAMARICACEAE

Tamarix pentandra Pall.	saltcedar, tamarisk	Yampa River, Teepee and Big Joe camps, Mather Hole, Laddie Park, Box Elder Green River, Kolb Camp, Harp Falls, Rippling Brook Limestone, State Line, Compromise camps

UMBELLIFERAE

Cicuta douglassii (DC.) Coult. & Rose	waterhemlock	Green River, Kolb Camp
cf. Cicuta sp.	waterhemlock	Green River, Limestone Camp

URTICACEAE

Urtica dioica procera (Muhl.)Wedd.	nettle	Green River, Jones Hole

* Identified in the field.
** Introduced species.

[1] Plants collected during field work; family, genus and species given in alphabetic order; locations of collected and observed taxa included.